JOURNAL
OF THE
WASHINGTON ACADEMY OF SCIENCES
VOL. VI AUGUST 19, 1916 No. 14

PHYSICS.—*Recent improvements in the petrographic microscope.* F. E. WRIGHT, Geophysical Laboratory.

1. *Sliding objective changer.* In modern microscopes two forms of objective changer are in common use. On ordinary, non-polarizing microscopes (biological, etc.) the revolving nose piece is universally favored and serves the purpose well. In case exact centering is required, however, the revolving nose piece is mechanically inadequate and for this reason has never proved satisfactory in petrographic microscope work. In its place some form of objective clamp is usually adopted in polarizing microscopes; but with such a clamp each change from one objective to another involves a number of different operations which together require from 10 to 30 seconds to accomplish; in the course of a day's work, especially with fine grained and artificial preparations, this may consume 5 and even 10 per cent of the observer's available time. From an efficiency standpoint such a procedure cannot be considered satisfactory; but it can fortunately be remedied by a simple arrangement such that the time involved in changing objectives is of the order of half a second with the result that the total time is reduced to a fraction of 1 per cent of the day's working hours. The new device has been in constant use for nearly a year and has proved its usefulness.

The device is shown in figure 1 and consists simply of a sliding brass carriage in which are mounted two objectives in excentric conical steel rings, so cut that there is no change in focus in passing from one objective to the second. Each objective is

centered, once for all, in a vertical direction by rotation in an excentric steel supporting ring and in a horizontal direction by one of the hardened steel screws *A* or *B;* against the flanges of these screws the hardened steel face-plates of the carriage strike. Mechanically the bearing surfaces are wide and the objectives return to exact center and focus on changing. For most petrographic work two objectives only are required (high power, *E. F.* = 4 mm., and low power *E. F.* = 16 mm.) and one carriage suffices for the purpose. But occasionally objectives of other focal length are desired; these are then mounted on a second slider which is slipped into the mount in place of the first carriage. In this operation the semi-circular flange of the stop screw *B* (fig. 1) is first turned through 90° to allow the slider to pass.

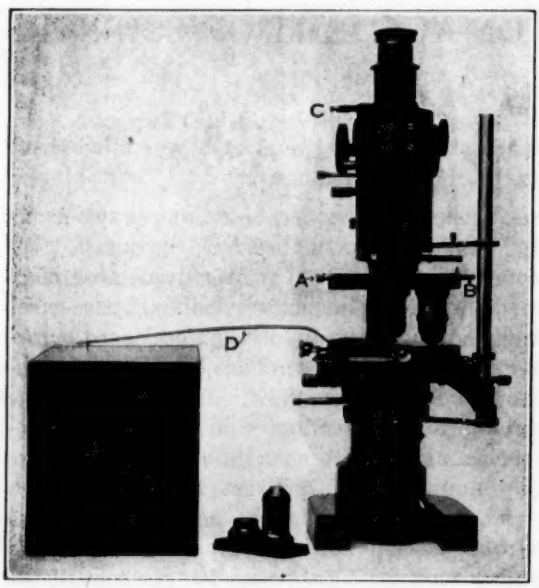

Fig. 1. Petrographic microscope with new accessories: *A*, sliding objective changer; *B*, lens system for removal of astigmatism caused by analyzer; *C*, prism for observation of interference figures; *D*, device for use in the accurate measurement of extinction angles.

2. *The removal of the astigmatism introduced by the analyzer.* It has long been known that the introduction of the analyzer into the optical system seriously disturbs the optical quality of the image by introducing into it astigmatism and other defects.

Tissot and Pellin[1] sought to remove the astigmatism by means of a cylindrical lens placed above the eye lens of the ocular, but this arrangement proved to be only partially successful. Recently S. Becher[2] has studied the question in detail and suggests that the astigmatism can best be obviated by converting the microscope lens system into a telecentric system such that the rays pass through the analyzer as parallel beams. He proposes to accomplish this by using objectives specially corrected for image plane at infinity and to employ a weak positive lens above the analyzer to focus the parallel beams emerging from the nicol on the image plane of the eyepiece.

Experience has shown that Becher's plan to remove astigmatism by means of the telecentric lens system is feasible; but that other arrangements in the optical system are better adapted from a practical standpoint to accomplish the same purpose.

In the first place it is not convenient to require a specially computed objective for the observations in polarized light. Such objectives would have to be computed and made specially, and would serve only a special purpose. On taking up this matter with the Bausch & Lomb Optical Company it was suggested to the writer by Dr. H. Kellner[3] that a weak negative lens may be used below the nicol in conjunction with an ordinary objective, the negative lens to be of such focal length that the rays converging toward points in the image plane are converted into parallel beams and pass as such through the nicol. After emergence from the nicol they are rendered again convergent by means of a weak positive lens. The new plan was tried out nearly a year ago and has been regularly introduced since then on all research model microscopes constructed by the Bausch & Lomb Optical Company. For observations in parallel polarized light the new scheme works well and is satisfactory, but for observations in convergent polarized light it is useless, as is also the plan suggested by Becher.

[1] Comptes Rendus, **145**: 866–877. 1907.

[2] SIEGFRIED BECHER. *Über den Astigmatismus des Nicols und seine Beseitigung im Polarisations Mikroskop.* Ann. d. Physik: 4 Folge, **47**: 285–364. 1915.

[3] Letter of September 18, 1915.

Some of the most important measurements in petrologic microscopic work are made in the interference figure (optic axial angles and angular distances of isochromatic curves), and it is highly desirable that a method be available for eliminating the astigmatism and distortion from the interference figure,[4] as this seriously affects the degree of attainable precision. The interference figure is formed in the upper focal plane of the objective and the rays from its points are imaged, after passage through the analyzer and Bertrand lens, in the image plane of the eyepiece. In order to fulfil the condition that these rays enter the nicol as parallel beams, a weak positive lens must be introduced below the analyzer in such a position that the lower focal plane of the lens coincides with the plane of the interference figure. The rays after emergence from the analyzer are focussed by means of a weak positive lens in the image plane of the eyepiece. In effect this arrangement is that of two astronomical telescopes in series, the objective and lens below the nicol forming the first system, the lens above the polarizer and the eyepiece the second.

The practical problem, to combine the arrangement for eliminating astigmatism in parallel polarized light with that for convergent polarized light, is being met on the writer's microscope as follows: The negative lens and the positive lens required for the correction in parallel polarized light are fitted below and above the nicol respectively. To pass to convergent polarized light a positive lens is introduced in a slider in a slot between the analyzer and the objective; the focal length of this lens is such that its combination with the negative lens functions as a positive lens whose lower focal plane coincides with the plane of the interference figure. By this arrangement the interference figure is imaged slightly magnified (magnification approximately equal to the ratio of the focal length of upper positive lens to that of combination positive and negative lens below the analyzer) in the image plane of the eyepiece. In the case of small sections it is essential that all extraneous light from adjacent sections be excluded from the field; this can only be done by means of a stop

[4] See, F. E. WRIGHT. *Methods of petrographic microscope research.* Carnegie Institution of Washington, Publication No. 157, pp. 53–56. 1911.

in the image of the object plane. To accomplish this a sliding stop or iris diaphragm is introduced just beneath the sliding positive lens; by raising the objective the object is imaged in the plane of the stop, which allows only light from the particular section to pass. In the writer's microscope the correct position of focus is determined by means of the Bertrand lens which together with the ocular constitutes a weakly magnifying microscope focussed on the plane of the stop.

For most petrographic microscope work relatively low magnifications are used and the astigmatism introduced by the nicol is not a serious factor either in parallel or convergent polarized light. It would seem, therefore, that except in work of precision the above changes are in a sense refinements which add to the complexity of the instrument.

The assertion of Becher that the telecentric system permits the use of the oblique end type of nicol prism as analyzer is not borne out either by theory or by practice, because the oblique ends of such a prism rotate the plane of vibration of the emergent rays and are under all conditions inferior to the square end type such as the Glan-Thompson prism.

3. *The prism method for the observation of interference figures.* In 1906 the writer described[5] a simple method for the observation of interference figures by the Lasaulx method; the method consisted essentially in reflecting, by means of a prism mounted in a slider, the rays of light from the axis of the microscope out to a path outside the tube of the microscope, thus obviating the necessity of removing the eyepiece each time an interference figure is observed by the Lasaulx method. Improvements in this device have been made by replacing the two reflecting prisms by a single doubly reflecting prism; in reducing the size of the prism so that it cuts out a small part of the center of the field and thus serves as an effective stop sufficiently small to include only one section or grain of ordinary size; and in placing the prism slider directly beneath the field lens of the ocular so that the part of the field covered by the prism can be viewed directly

[5] Am. J. Sci. (Series 4), **22**: 19. 1906.

(fig. 1, *C*). These improvements have greatly extended the usefulness of this device, which experience has shown to save an appreciable amount of the observer's time in routine work.

4. *A device for use in the accurate measurement of extinction angles.* The measurement of an extinction angle involves two operations: (*a*) the setting on the position of darkness, and (*b*) the placing of some definite crystallographic direction, as a cleavage line or a line of crystal growth, parallel with one of the cross hairs in the eyepiece. The precision of the second operation depends largely on the quality of the crystallographic direction which is used as line of reference; in case this is sharply developed there is no difficulty in setting with a precision of 1′ of arc. The first operation, on the other hand, depends on a number of factors, one of the most important of which is the sensitiveness of the eye of the observer and his personal equation. The eye is sensitive down to a certain value (threshold value) below which the field appears dark. Under ordinary conditions of illumination in microscope work there is a region of 1° to 2° within which the average birefracting plate between crossed nicols can be rotated and yet appear to be dark. The common practice in measuring extinction angles is to ascertain the position of maximum darkness on rotation of the crystal plate a number of times to the right and stopping at the position judged to be the darkest; this operation is repeated a certain number of times; and similarly for an equal number of rotations to the left. The average of these readings is then considered to be the most probable position of darkness. In principle this method is excellent, especially if the half shade principle be introduced to increase the precision of each setting; but in practice there is a tendency, which is exceedingly difficult to correct, for the observer unconsciously to attach special importance to the first reading and thus to give it undue weight.

In all measurements of this type, where settings of relative intensity are made, it is essential for accurate work to eliminate this element of the undue weighting of first readings and to make each setting without knowledge of its agreement or lack

of agreement with foregoing readings. Only in this way can a proper random distribution of errors be obtained which will furnish a good probable value.

To apply this principle to the measurement of extinction angles a simple flexible arm of brass was cut out and attached by means of tightly fitting plugs into the clip holes on the microscope stage (fig. 1, *D*). At the other end of the arm a needle point is soldered. To record a setting, a mark by the needle point is made in a sheet of millimeter cross section paper mounted in proper position on a block of wood (shown greatly foreshortened in fig. 1). A convenient length of radius to use is 28.66 cm; each degree on the arc of the circle is then 5 mm. and readings can readily be made to tenths of a degree and even to fiftieths.

Experience with this simple device which can easily be made in an hour has shown that much time can be saved by its use. Settings are made by simply pressing down the needle and no readings are required. A number of settings are made with clockwise rotation of the stage, and an equal number with counter-clockwise rotation. By reference to the graduated circle on the microscope stage the angular position of the average position of the points punched in the paper can be read off directly and with it the most probable extinction position. Experience has shown that the eye can estimate the average center of a series of points grouped about the center with sufficient accuracy for practical purposes. The actual angular position of each point can, of course, be ascertained and an arithmetical average then taken, but for most purposes this is unnecessary.

It is of interest to note that the mean position of clockwise rotation may be situated a whole degree away from the mean position of counter-clockwise rotation, thus showing the importance of making measurements by approaching the position of extinction from the right and from the left as well. The above device is useful also in enabling the observer, especially if he be a student, to ascertain the probable error of the single settings and at the same time to increase the precision of his measurements without extra labor.

PHYSICS.—*The calculation of Planck's constant* C_2.[1] J. H. DELLINGER, Bureau of Standards.

This constant, which is of great importance in high temperature measurements and in atomic theory, has heretofore been obtained from radiation data by processes involving the use of a graph. It may be calculated directly and very simply from any two observations. A solution of Planck's equation for C_2 in terms of the ratio of energies at any two wave lengths and temperatures is readily obtained, C_2 appearing in a correction term in the solution. The various relations which have been used for obtaining C_2 from radiation data are deducible as special cases.

The equation for two observations of wave length at constant temperature is of special interest; the following approximate expression is sufficiently exact for most cases.

$$C_2 = \frac{\lambda_1 \lambda_2 \theta}{\lambda_2 - \lambda_1}\left[\log \frac{J_2}{J_1} + 5 \log \frac{\lambda_2}{\lambda_1} - e^{-\frac{C_2}{\lambda_2 \theta}}\right]$$

An approximate value of C_2 always suffices for the last term. This general method of solution is superior to the method of equal ordinates. No curve has to be drawn, and the calculations are not limited to particular pairs of points. The method is more powerful in determining whether an observed curve fits the Planck equation. In fact, curves which give normal values for C_2 by the method of equal ordinates were found to give very high values when calculations were made by this method for two points both on the same side of the maximum.

Points on the Planck curve for which Wien's displacement law holds, in particular the maximum of the curve, have been considered as furnishing additional ways of determining C_2. Such methods are debarred by lack of accuracy, and in fact these special points may themselves be obtained most accurately and conveniently by the same process of using two observations which is used for obtaining C_2. Substantially the same simple equation suffices to determine C_2 and all the special points.

[1] Detailed paper to appear as Bureau of Standards Scientific Paper No. 287 (Bull. Bur. Stds., **13**: 535–545). 1916.

PHYSICS.—*Some new designs of radiometers.* W. W. COBLENTZ, Bureau of Standards.

In continuing the improvement of stellar radiometers several new designs of instruments were considered and some of the preliminary tests of their efficiency appear to be of sufficient importance to warrant publication.

When a very thin strip of blackened metal, e. g. a bolometer strip, is exposed to radiation it becomes warmed and it in turn emits radiation. In previous investigations of the diffuse reflecting power of various substances[1] and of the behavior of an absolute thermopile[2] it was found that this warming of the receiver is quite appreciable, and that this receiver can be a very efficient secondary source of radiation which, in turn, can be used to operate a radiometer. The utilization of this secondary source of radiation can be accomplished by placing the receiver at the center of an accurately ground hollow sphere having an opening to admit radiation. In this case one would utilize the "re-radiation" which has to be very carefully excluded in diffuse reflection measurements.[3]

Another logical method for utilizing this radiation is the employment of multiple receivers, one being placed back of another; for example, a thermopile receiver back of a bolometer strip, or one bolometer strip (or thermopile receiver) back of another. It is with this method that the present paper is chiefly concerned.

[1] Bull. Bur. Stds., **9**: 283. 1913.

[2] Bull. Bur. Stds., **11**: 157. 1914.

[3] PASCHEN (Ber. Berliner Akad., p. 409. 1899) appears to have been the first one to use a hemispherical mirror in front of a bolometer in order to "blacken" it. The device has been used extensively by the writer (Bull. Bur. Stds., **4**: 392. 1908). In spectral radiation work care must be exercised to avoid reflection of radiation from the adjacent parts of the spectrum upon the bolometer strip. In investigations where it is unimportant whether some of the incident beam of radiation falls upon a reflecting surface at the rear of the receiver before it falls upon the receiver (i.e. in cases where it is unimportant whether the complete beam of incident radiation is completely intercepted by the receiver) it is possible to place the receiver at the center of an accurately made hollow sphere as just mentioned. PFUND (Phys. Rev. **34**: 288. 1912) claims a very large increase in sensitivity as the result of using a thermojunction at the focus of a spherical mirror.

The efficiency of such a device was tested in the following manner. Two strips of very thin platinum, such as is used in bolometers (thickness about 0.001 mm.), about 6 by 20 mm. in area were mounted over slits cut in cardboard which was 0.45 mm. thick. Both sides of these strips were painted with a thin coat of lamp black and covered with soot from a sperm candle. The thermopile receiver was 1.8 by 16 mm. Slits of bright aluminum, 0.85 mm. thick, were placed in front of the thermopile or in front of the blackened platinum strips when they were in front of the thermopile. The distance between the thermopile receiver and the platinum strip (and between the two platinum strips) was 0.45 mm. When the thermopile was exposed directly to a standard of radiation the deflection was 12.15 cm.; when one platinum strip intervened the deflection was 5.88 cm.; and when the two platinum strips were in front of the thermopile the deflection was 3.57 cm.

The multiple bolometer receiver. Since there is but little difference between the radiation sensitivity of a bismuth-silver thermopile and a bolometer, the above tests show that the radiation sensitivity of a bolometer can be increased by 50 per cent by having the receiver (the arm of the bridge) consist of two strips, one back of the other, the front strip being exposed to radiation. By using three strips placed one back of another the galvanometer deflection would be increased by about 80 per cent, and by using four strips (joined in series, or a single strip folded three times) the deflection will be double that produced by the front strip. The sensitivity of the whole combination would be further increased by placing this multiple receiver at the focus of a hemispherical mirror.

The bolo-pile. This is a combination of a single bolometer strip, close back of which is placed the receiver of a thermopile. The latter is so constructed that the pairs of receivers are in two rows corresponding to the two bolometer strips. In this manner the heating produced by the current passing through the bolometer strips will produce no deflection in the thermopile circuit. The manner of connecting the bolometer and the thermopile

circuit to the galvanometer will depend upon the relative change in voltage of the two circuits when the receiver is exposed to radiation. If the error due to shunting is too great when the two circuits are joined to the same binding posts, the bolometer current can be passed through one galvanometer coil and the thermopile current through another coil.

The simplest and probably the most useful arrangement is a bolometer consisting of two branches of thin narrow strips of platinum close back of which is placed a thermocouple. In measuring the heat from stars a gain of only 50 per cent in sensitivity is worth considering.

The multiple thermocouple receiver. The use of two thermocouples, joined in series, with the receivers one back of the other, has not yet proved to be so efficient, because of the greater heat capacity of the thermocouple receiver used as compared with a bolometer. The comparison of this combination with the two preceding instruments, and with a single thermocouple (or bolometer) in the focus of a spherical inclosure, in which all the parts are reduced to the dimensions which would be used in measuring stellar radiations, is in progress.

In conclusion it may be added that as a result of the writer's previous measurements of stellar radiation[4] the conclusion was arrived at that, in order to do much successful work in stellar radiometry, it will be necessary to have a 100-fold greater sensitivity than that previously employed. This gain in sensitivity was to be attained by increasing the light-gathering power of the telescope 5 times, the sensitivity of the galvanometer 10 times, and the radiometer sensitivity 2 times. In a paper[5] just published data are given showing an increase of more than 10 times in the galvanometer sensitivity, while the present paper indicates the way to double the radiometer sensitivity. Apparently then it remains to find a suitable mirror and funds to operate it.

[4] Bull. Bur. Stds., **11**: 613. 1914.
[5] Bull. Bur. Stds., **13**: 423. 1916.

PHYSICS.—*Criteria for gray radiation.* P. G. NUTTING, Rochester, New York. (Communicated by N. E. Dorsey.)

If the logarithm of the energy radiated from a body within a short range of wave lengths be plotted against the reciprocal of the absolute temperature, the result is known to be a sensibly straight line over a wide range of temperatures. These logarithmic isochromatic lines pass through a common point in some cases, not in others. Benedict[1] concludes that this stigmatic condition is characteristic of gray radiation, while the lack of it means that the radiation is selective. Hyde[2] from his own data on lamp filaments concludes that the stigmatic condition is insufficient as a criterion for grayness. Foote and Fairchild[3] have shown further that the stigmatic condition may hold even for a body known to be strongly selective.

The mathematical side of the problem appears to have been neglected, although capable of rather simple treatment. Let the equilibrium radiation from a "black body" be represented by

$$J = B_1 \lambda^{-5} e^{-\frac{B_2}{\lambda T}} \tag{1}$$

in which B_1 and B_2 are independent of wave length and temperature. Also let

$$E = C_1 \lambda^{-n} e^{-\frac{C_2}{\lambda T}} \tag{2}$$

represent radiation from some body, but not in equilibrium with it.

From (1)

$$\log J = \log (B_1 \lambda^{-5}) - \frac{B_2}{\lambda T} \tag{3}$$

hence for any fixed wave length, $\log J$ is a linear function of $1/T$. Writing (3)

$$y = a - bx \tag{4}$$

it is seen to represent a family of straight lines whose Y intercept is a and whose direction tangent is b.

But the general representation of a stigmatic pencil of lines passing through the point (x_0, y_0) is

$$y - y_0 = -b\,(x - x_0), \tag{5}$$

[1] E. BENEDICT. Ann. d. Physik, (4) **47**: 641. 1915.
[2] E. P. HYDE. Ann. d. Physik, (4) **49**: 144. 1916.
[3] FOOTE and FAIRCHILD. This JOURNAL, **6**: 193. 1916.

hence the necessary and sufficient condition that the pencil of lines represented by (4) be stigmatic is that a be a linear function of b,

$$a = y_0 + bx_0 \tag{6}$$

x_0 and y_0 being constants independent of both wave length and temperature.

This condition however is *not satisfied* even for equilibrium radiation, for $a = \log (B_1 \lambda^{-5})$ and $b = B_2/\lambda$, and neither of these expressions can be a linear function of the other. Over but a moderate range of wave lengths the expression holds to a fair approximation (probably to within the limits of experimental error). For, let $\lambda = \lambda_0 (1 \pm \delta)$ where δ is so small that its square may be neglected in comparison with its first power. In this case a and b are both linear functions of δ and hence of one another.

Consider now the free radiation represented by (2) whether gray or selective. The parameters C_1, n and C_2 vary not only from surface to surface but (in general) with both wave length and temperature; in other words, the equation is too simple to represent free radiation. However, the stigmatic condition may be applied even though no parameters are constant. If the data indicate that a number of logarithmic isochromatic lines pass through a common point, then an equation similar to (6) must hold over the range of wave lengths covered by the data. Hence, for any variation $da = x_0\, db$; for example, $da/d\lambda = x_0\, db/d\lambda$. The linear relation (6) requires

$$\log C_1\lambda^{-n} = y_0 + \frac{C_2 x_0}{\lambda} \tag{7}$$

Hence, by substitution in (2), in any region within which the stigmatic condition holds, even though C_1, n and C_2 vary,

$$\log \frac{E}{E_0} = \frac{C_2}{\lambda}\left(\frac{1}{T_0} - \frac{1}{T}\right) \tag{8}$$

where E_0 and T_0 are *fixed constants* such that $\log E_0$ and $1/T_0$ are the coordinates of the point of stigmatism.

This is of the same form as the Paschen-Wanner equation, used so much in monochromatic pyrometry, but with a some-

what different interpretation. Imposing the stigmatic condition has eliminated both n and C_1 with their possible variations. It is well known from experimental data that this form of equation holds well and that the stigmatic condition is frequently fulfilled.

For gray radiation $\log(E/J)$ is by definition independent of wave length. In case C_1, n and C_2 are all constant, as with equilibrium radiation, the stigmatic condition can hold for but a limited range of wave lengths. The gray condition in the general case with varying parameters gives

$$\log \frac{C_1 \lambda^{-n+5}}{B_1} = \text{constant} + \frac{C_2 - B_2}{\lambda T}$$

This is consistent with the stigmatic condition (7) for free radiation, but either may be true without the other.

We have shown that the logarithmic isochromatic lines representing equilibrium radiation do not form a stigmatic pencil except for a limited range of wave lengths. For free radiation, the stigmatic condition gives an equation known to be of wide validity. The stigmatic condition and the condition for grayness may both be satisfied, but either may hold without the other.

PHYSICS.—*Summary of experiments on the silver voltameter at the Bureau of Standards.*[1] E. B. ROSA AND G. W. VINAL, Bureau of Standards.

The investigation of the silver voltameter at this Bureau was first begun by the late Dr. K. E. Guthe in 1904. His results were published in two papers about a year later. In 1907 the work was again taken up by Dr. N. E. Dorsey in cooperation with the present authors, but the results obtained at this time did not confirm the newly published experiments of the National Physical Laboratory, and new difficulties arose which were not understood. These experiments were not published. In the following year the work was resumed and preparations were made for a very thorough study of the silver voltameter. The voltameter received added importance when the ampere was adopted by the London Electrical Congress as the second funda-

[1] A more detailed summary will appear as Bureau of Standards Scientific Paper No. 285 (Bull. Bur. Stds., **13**: 479–514. 1916).

mental electrical unit, so that the investigations which the present authors began in the summer of 1908 have passed beyond the original plans in scope and duration. This has also been due, in large measure, to the numerous and intricate sources of error which were discovered in the course of the work, all of which required painstaking investigation.

Other experimenters who have cooperated with us at various times during the course of the work are Dr. A. S. McDaniel, Prof. S. J. Bates, Prof. G. A. Hulett, and Mr. Wm. M. Bovard. The results of these investigations have been published in a series of eight papers.[2]

A few of the principal results may be summarized as follows:

1. The effect of filter paper on silver nitrate solutions (whether the paper is used in the voltameter itself, as has been commonly done, or whether it is used in the preparation of the silver nitrate solution) was shown to be serious and to result in the formation of colloidal silver. This effect of the filter paper is due to the formation of reducing agents from the oxycellulose of the paper itself and is not due to impurities.

[2] E. B. Rosa and G. W. Vinal. Bur. Stds. Sci. Paper No. 194 (Bull. Bur. Stds., **9**: 151. 1913); summaries in this Journal, **2**: 451. 1912; Elec. World, **60**: 1261. 1912; Elektrotech. Zs., **34**: 232. 1913.

E. B. Rosa, G. W. Vinal, and A. S. McDaniel. Bur. Stds. Sci. Paper No. 195 (Bull. Bur. Stds., **9**: 209. 1913); summaries in this Journal, **2**: 509. 1912; Elec. World, **60**: 1262. 1912; Elektrotech. Zs., **34**: 233. 1913.

E. B. Rosa, G. W. Vinal, and A. S. McDaniel. Bur. Stds. Sci. Paper No. 201 (Bull. Bur. Stds., **9**: 493. 1913); summaries in this Journal, **3**: 40. 1913; Elec. World, **61**: 84. 1913; Elektrotech. Zs., **34**: 1168. 1913.

G. W. Vinal and S. J. Bates. Bur. Stds. Sci. Paper No. 218 (Bull. Bur. Stds., **10**: 425. 1914); Journ. Am. Chem. Soc., **36**: 916. 1914; summary in this Journal, **4**: 69. 1914.

E. B. Rosa, G. W. Vinal, and A. S. McDaniel. Bur. Stds. Sci. Paper No. 220 (Bull. Bur. Stds., **10**: 475. 1914); summaries in this Journal, **4**: 52. 1914; Elec. World, **63**: 373. 1914; Elektrotech. Zs., **35**: 789. 1914.

G. A. Hulett and G. W. Vinal. Bur. Stds. Sci. Paper No. 240 (Bull. Bur. Stds., **11**: 553. 1915); Journ. Phys. Chem., **19**: 173. 1915; summary in this Journal, **4**: 593. 1914.

G. W. Vinal and W. M. Bovard. Bur. Stds. Sci. Paper No. 271 (Bull. Bur. Stds., **13**: 147. 1916); Journ. Am. Chem. Soc., **38**: 496. 1916; see also this Journal **6**: 222. 1916.

E. B. Rosa and G. W. Vinal. Bur. Stds. Sci. Paper No. 283 (Bull. Bur. Stds., **13**: 447. 1916); see also this Journal, **6**: 500. 1916.

2. The appearance of the deposit is altered by the presence of impurities in the solutions (such as those resulting from filter paper). Pure solutions give crystalline deposits of very pure silver, but colloids, if present, break up the crystals and produce striated deposits which are too heavy to represent accurately the amount of electricity which passed through the voltameter.

3. Many forms of voltameter have been compared. The Bureau has found that the most satisfactory are the porous cup voltameter and the new form devised by Mr. F. E. Smith of the National Physical Laboratory.

4. The Bureau has devised means of preparing pure silver nitrate and suitable tests for it, so that an electrolyte of a uniformly high state of purity can be prepared. These tests are for acidity and for reducing agents. The Bureau has also found that the agreement between the results obtained from large and from small sizes of voltameters, used simultaneously, is a valuable test of purity; impure solutions (except for acid) invariably give heavier deposits in the large size voltameters. This phenomenon we have called the *volume effect.*

5. The temperature coefficient of the voltameter is found to be zero.

6. Tests of the purity of the silver deposits show that when made from pure electrolyte, the impurities included with the silver crystals represent on the average only 0.004 per cent of the weight of the deposit.

7. The absolute electrochemical equivalent of silver was found to be 1.11800 mg. per coulomb and the voltage of the Weston normal cell was found to be 1.01827 volts at 20°C.

8. Comparisons with the iodine voltameter were made and the ratio, the amount of silver deposited to the amount of iodine deposited by the same current, was found to be 0.85017, which, corrected for the inclusions in the silver deposits, gives 0.85013. The electrochemical equivalent of iodine in absolute measure was computed to be 1.31507 mg. per coulomb.

The value for the faraday on the basis of the absolute electrochemical equivalent of silver and of iodine and their atomic weights is as follows:

On the silver basis (Ag = 107.88)	96,494
On the iodine basis (I = 126.92)	96,512
Mean	96,503

The best round value which can be assigned to this constant appears to be 96,500 coulombs.

A brief history of the specifications for the voltameter, as well as revised specifications proposed by the Bureau of Standards, will be given in the detailed paper.[3] As no adequate specifications have been adopted since the London Conference of 1908 it is hoped that the carefully drawn specifications which the Bureau will present may be adopted as a whole or in part, whenever it is possible to reach an international agreement. In any case, for the present, these specifications will be available for the guidance of such investigators as may wish to use the silver voltameter.

An appendix to the paper will contain an extensive bibliography of the subject.

CHEMISTRY.—*A note on the sulphone-phthaleins as indicators for the colorimetric determination of hydrogen-ion concentration.*[1] HERBERT A. LUBS and WILLIAM MANSFIELD CLARK, Bureau of Animal Industry.

In a previous paper[2] from this laboratory there were described several new indicators of the sulphone-phthalein series and an improved method for the preparation of those previously made by others. In our subsequent work on indicators suitable for the colorimetric determination of hydrogen-ion concentration, we have investigated other compounds of this series and have found another that promises to be particularly useful for this purpose; namely, dibrom-o-cresol-sulphone-phthalein. We have also found that slight modifications in the methods of preparation of some of the indicators described in our earlier paper will insure

[3] Shortly to appear as Bur. Stds. Sci. Paper No. 285 (Bull. Bur. Stds., **13**: 479–514. 1916).

[1] From the research laboratories of the Dairy Division, Bureau of Animal Industry. Published by permission of the Secretary of Agriculture.

[2] Journ. Wash. Acad. Sci., **5**: 609. 1915.

better products. These modifications will be discussed under the indicators in question. At the end of the article will be found a list of the sulphone-phthaleins which have been investigated in this laboratory, with their color changes and the ranges over which the changes occur. An account of our investigations of the more useful indicators will shortly appear in the Journal of Bacteriology.

O-CRESOLSULPHONE-PHTHALEIN

Ten grams of the chloride of o-sulphobenzoic acid, 10 grams of freshly fused zinc chloride, and 15 grams of o-cresol were heated for 6 hours at 110°–120°, instead of at 165°–170° as previously recommended. At the lower temperature a purer product was obtained.

DIBROM-O-CRESOL-SULPHONE-PHTHALEIN

This indicator was prepared practically as described by Sohon.[3] Two grams of o-cresolsulphone-phthalein was suspended in 10 cc. of glacial acetic acid and 2 cc. of bromine was added. The flask was allowed to stand over night and the reddish-white crystals were filtered off the next morning. These crystals can be recrystallized by dissolving in boiling toluol and allowing the solution to cool.

The color changes are from yellow to a brilliant purple and occur over the range P_H^+ 5.2 to P_H^+ 6.8. A 0.04 per cent aqueous solution of the mono-sodium salt is satisfactory for the indicator solution.

THYMOLSULPHONE-PHTHALEIN

This compound can be prepared more satisfactorily by heating the mixture of the chloride of o-sulphobenzoic acid, zinc chloride, and thymol at 100°–110° for 6 hours, instead of at 140° as recommended in our previous paper.

DIBROMTHYMOL-SULPHONE-PHTHALEIN

In our earlier paper this compound was described simply as brom-thymol-sulphone-phthalein. Subsequent analyses have shown that it is the dibrom compound.

[3] Amer. Chem. Journ., **20**: 257. 1898.

ANALYSES

I. 0.1456 gram gave 0.0881 gram AgBr.
II. 0.1865 gram gave 0.1158 gram AgBr.
Calculated for $C_{27}H_{28}Br_2O_5S$, 25.6 per cent Br.
Found, I, 25.8 per cent; II, 26.4 per cent.

TABLE 1

COLOR CHANGES AND APPROXIMATE RANGES OF THE VARIOUS SULPHONE-PHTHALEINS

INDICATOR	COLOR CHANGE	RANGE P_H
Thymolsulphone-phthalein†	Red—yellow	1.2–2.8
Tetrabrom-phenolsulphone-phthalein	Yellow—blue	2.8–4.6
Tetrachlor-phenolsulphone-phthalein*	Yellow—blue	2.8–4.6
Dibrom-o-cresol-sulphone-phthalein	Yellow—purple	5.2–6.8
Dibromthymol-sulphone-phthalein	Yellow—blue	6.0–7.6
Phenolsulphone-phthalein	Yellow—red	6.8–8.4
o-Cresolsulphone-phthalein	Yellow—red	7.2–8.8
Phenol-nitro-sulphone-phthalein*	Yellow—red	6.8–8.4
α-Naphtholsulphone-phthalein	Yellow—blue	7.4–9.0
Thymolsulphone-phthalein	Yellow—blue	8.0–9.6
Thymol-nitro-sulphone-phthalein*	Yellow—blue	8.0–9.6
Carvacrolsulphone-phthalein*	Yellow—blue	8.0–9.6

* These compounds were prepared only in small amounts. Upon investigation we found that they showed no advantage over compounds more easily prepared. On this account we did not attempt to find the best conditions for their preparation, and for this reason the details of methods for their preparation are not given.

† This indicator shows color changes in both alkaline and acid solutions. Between P_H 3 and P_H 8.0 its solution is yellow in color.

CHEMISTRY.—*The colorimetric determination of the hydrogen-ion concentration of bacteriological culture media.*[1] WILLIAM MANSFIELD CLARK and HERBERT A. LUBS, Bureau of Animal Industry.

In a previous note[2] we described some new indicators which are especially useful in colorimetric determinations of hydrogen-ion concentrations. In the present number of this JOURNAL we present some further notes.

[1] From the research laboratories of the Dairy Division, Bureau of Animal Industry. Published by permission of the Secretary of Agriculture.

[2] LUBS, H. A., and CLARK, W. M. Journ. Wash. Acad. Sci., **5**: 609. 1915.

The chief object of these studies has been to assemble a set of indicators which may be used from about $P_H = 1.0$ to $P_H = 10.0$ and which will have such brilliancy and such reliability that they may be used in the colored and turbid solutions handled by the bacteriologist. Preliminary tests had shown the value of some of the indicators of the methyl red and sulphone-phthalein types. We have now concluded a more extensive investigation in which over four hundred electrometric measurements were made of the hydrogen-ion concentrations of a variety of culture media and cultures with simultaneous measurements by the colorimetric method.

In these studies we have had to test the applicability of the indicators upon a heterogeneous collection of solutions such as are used in bacteriological work and, in order to subject the method to the severe conditions which it will have to meet if applied to many bacteriological problems, we have devoted most of our attention to measurements of colored and turbid solutions. The material was therefore not favorable for any systematic study of the so-called "protein and salt errors." Furthermore, since we consider the colorimetric method to be only supplementary to the more precise electrometric method, we confined our attention to very simple and rapid colorimetric procedures, such as are available to all and such as are convenient for handling the enormous number of tests which certain classes of research and routine bacteriological work require. The electrometric measurements, on the other hand, were made with care and with the improved equipment described by Clark[3] and by Clark and Lubs.[4]

The details of these extensive comparisons between the electrometric and the colorimetric determinations are beyond the scope of this brief article. They will be published elsewhere, together with a discussion of the applications of the colorimetric method in bacteriology. The main results may be briefly summarized as follows.

Since the colorimetric method, if applied extensively in routine, should be made as convenient as possible, we devised and carefully

[3] CLARK, W. M. Journ. Biol. Chem., **23**: 475. 1915.
[4] CLARK, W. M., and LUBS, H. A. Journ. Biol. Chem., **25**: 479. 1916.

studied a new set of standard buffer solutions which has several advantages over those formerly used. The details of this part of our investigation have recently been published.[5]

A new set of indicators has been assembled. Each of them has been studied sufficiently to enable us to make a selection of the most promising. The selection is listed in table 1, together with the short names we suggest for laboratory parlance. In this table are included the apparent dissociation constants. These constants, which are, of course, not the true dissociation constants, were determined by the method of Salm.[6] While they are only approximate, they are probably accurate enough to be used by those who may wish to apply them to titrimetric problems (see Bjerrum).[7] We have used them in our more detailed paper merely to illustrate some points in the discussion and to determine the approximate theoretical limits of P_H within which the several indicators may be used. The limits so found are in substantial agreement with those found empirically. They are given in table 1.

TABLE 1

SELECTION OF INDICATORS

CHEMICAL NAME	SHORT NAME	K AS P_H	USEFUL RANGE P_H
Thymolsulphone-phthalein (acid range)..	Thymol blue	1.7	1.2–2.8
Tetrabrom-phenolsulphone-phthalein.....	Brom-phenol blue	4.1	2.8–4.6
Ortho-carboxy-benzene-azo-dimethyl-aniline.....	Methyl red	5.4	4.4–6.0
Ortho-carboxy-benzene-azo-dipropyl-aniline.....	Propyl red	5.1	4.8–6.4
Dibrom-o-cresol-sulphone-phthalein	Brom-cresol purple	6.3	5.2–6.8
Dibromthymol-sulphone-phthalein	Brom-thymol blue	7.0	6.0–7.6
Phenolsulphone-phthalein.....	Phenol red	7.9	6.8–8.4
o-Cresolsulphone-phthalein.....	Cresol red	8.3	7.2–8.8
Thymolsulphone-phthalein (alk. range).	Thymol blue	8.9	8.0–9.6
o-Cresolphthalein.....	Cresol-phthalein	9.4	8.2–9.8

The confusing effect of the natural color of most culture media, vegetable extracts, etc., can be overcome to a large extent by using brilliant indicators such as the sulphone-phthalein indicators are, and by using the compensation method of Walpole.[8] The simple comparator

[5] CLARK, W. M., and LUBS, H. A. Journ. Biol. Chem., **25**: 479. 1916.
[6] SALM, E. Zeitschr. physik. Chem., **57**: 471. 1906.
[7] BJERRUM, N. Sammlung chem. u. chem.-tech. Vorträge, **21**: 1. 1915.
[8] WALPOLE, G. S. Biochem. Journ., **5**: 207. 1910.

of Hurwitz, Meyer, and Ostenberg[9] has been found useful for this purpose. We have also developed the dilution method, which consists in diluting about 2 cc. of the tested solution to 10 cc. with distilled water and measuring the P_H of this comparatively clear dilution. As is well known, this degree of dilution of solutions such as those tested has so small an effect on the P_H value that it can seldom be detected by the crude colorimetric method.

TABLE 2

DEVIATIONS OF COLORIMETRIC FROM ELECTROMETRIC P_H DETERMINATIONS OF BEEF INFUSION MEDIA

NO. OF DETERMINATIONS	INDICATOR	METHOD	AVERAGE	MEAN	MAXIMUM	MINIMUM
7	Brom-phenol blue...	comparator	−0.05	0.16	−0.38	−0.01
6	Methyl red.....	comparator	+0.10	0.11	+0.28	±0.00
4	Methyl red.....	dilution	+0.08	0.08	+0.18	±0.00
4	Propyl red.....	comparator	+0.08	0.08	+0.18	±0.00
2	Propyl red.....	dilution	±0.00	0.00	±0.00	±0.00
10	Brom-cresol purple..	comparator	−0.01	0.04	±0.07	±0.00
5	Brom-cresol purple..	dilution	−0.03	0.05	−0.14	−0.01
14	Brom-thymol blue..	comparator	−0.10	0.15	−0.25	+0.03
5	Brom-thymol blue..	dilution	−0.10	0.12	−0.26	+0.01
12	Phenol red.....	comparator	−0.04	0.04	±0.07	−0.01
8	Phenol red.....	dilution	−0.06	0.06	−0.12	−0.02
6	Cresol red.....	comparator	−0.03	0.03	−0.07	−0.01
3	Cresol red.....	dilution	−0.06	0.06	−0.11	−0.02
3	α-Naphtol-phthalein	comparator	−0.06	0.06	−0.12	−0.02
5	Thymol blue.....	comparator	−0.04	0.09	+0.14	−0.02
3	Thymol blue.....	dilution	−0.01	0.03	−0.06	−0.01
3	Phenol-phthalein....	comparator	+0.03	0.07	+0.14	−0.01
3	o-Cresol-phthalein ..	comparator	+0.03	0.07	+0.14	−0.01

The confusing effect of turbidity has been found to be more serious in many instances than the coloration usually encountered. This has been especially noticeable when either brom-phenol blue or brom-cresol purple was used. These indicators are red in thick layers of their solutions but blue in thin layers (at the proper P_H). The impossibility of establishing with such indicators a good comparison between a turbid solution, which can not be effectively viewed in any great depth, and a clear comparison standard of the same P_H is quite evident. With

[9] HURWITZ, S. H., MEYER, K. F., and OSTENBERG, Z. Bull. Johns Hopkins Hospital, **27**: 16. 1916.

such meagre aid as a small hand spectroscope afforded we were able to trace the nature of this "dichromatism" and to devise a light source with which the effect may be avoided. This source is simply a bank of ordinary electric lights from which the shorter wave lengths are screened by a translucent paper coated with an acid solution of phenol-sulphone-phthalein. With this screen fairly good measurements could be made with brom-phenol blue and excellent measurements with brom-cresol purple.

To illustrate the accuracy attained we may quote two tables. Table 2 summarizes some measurements made upon ordinary beef infusion media, some samples of which were quite dark or else turbid from addition of the acid or alkali used to bring the P_H value within the range of the indicator used.

In table 2 "comparator" indicates that the determination was made by the compensation method of Walpole. "Dilution" indicates that the tested solution was diluted five times with distilled water before measurement. "Average" deviation is the average of the positive and negative deviations when the electrometric value was subtracted from the colorimetric value in each case. "Mean" deviation is the average of the deviations, neglecting sign.

Table 3, which gives a few determinations made on urines is self-explanatory.

In regard to each indicator the following points may be noted:

Thymol blue, which was previously described for use in alkaline solutions, exhibits very brilliant color changes at high acidities. Although we have made only a comparatively few determinations in the acid range, the indicator seems to be reliable and promises to be useful in a zone of P_H for which there has been no very satisfactory indicator. It is hoped that others will try it in studies of the gastric contents. It should be useful for vinegars and for cultures of yeast and moulds.

Brom-phenol blue has not proved reliable when used in turbid solutions without a properly screened light, but for many approximate measurements it is useful. One may show, for instance, that material such as silage which is fermented by organisms of the *bulgaricus* type has about the same P_H as pure cultures of *B. bulgaricus*.

Methyl red has given some irregular results, for instance in Dunham's solutions, where frequently errors of 0.2 P_H were found. In media such as those used in the differentiation test of Clark and Lubs[10] methyl red has been found to give excellent results.

[10] CLARK, W. M. and LUBS, H. A. Journ. Infect. Diseases, **17**: 160. 1915.

Propyl red we have used chiefly to cover a zone between the ranges of methyl red and brom-thymol blue. This zone may now be studied with the aid of brom-cresol purple. The latter indicator is "dichromatic" like brom-phenol blue, but lends itself well to use in the screened light. It may be noted especially that this indicator is useful in that P_H zone within which the reactions of most urines fall.

TABLE 3

COLORIMETRIC AND ELECTROMETRIC DETERMINATIONS OF THE P_H OF URINES

INDICATOR	P_H COLORIMETRIC	P_H ELECTROMETRIC
Methyl red	5.5	5.54
	5.3	5.38
	5.5	5.55
	5.3	5.33
Propyl red	5.7	5.77
	5.6	5.62
	6.0	6.01
Brom-cresol purple	6.4	6.39
	5.9	5.88
	6.5	6.67
	6.1	6.01
	6.0	6.04
	6.4	6.36
	5.7	5.62
	5.7	5.77
	5.5	5.54
Brom-thymol blue	6.8	6.80
	6.5	6.67
	6.5	6.43
	6.4	6.38
Phenol red	6.8	6.80

With both thymol blue (alkaline range) and its dibrom derivative discrepancies between the colorimetric and electrometric determinations appear more like uncertainties in judgment than like consistent errors. In general, good agreement was found, but it is the unfavorable nature of the colors which we believe may lead to error.

Phenol red and cresol red are undoubtedly the most reliable indicators of the series.

In regard to phenol-phthalein we may say in the first place that neither it nor its homologue, ortho-cresol-phthalein, is as useful in the

solutions we have studied as the two-colored indicator thymol blue. In our experience a two-colored indicator is generally to be preferred for hydrogen-ion determinations, especially when the solution itself is colored. On the other hand these phthaleins can be used at slightly higher P_H than thymol blue and consequently must be used in certain instances. Of the two we prefer the cresol compound, because of its greater brilliancy. Indeed we now use the cresol compound in place of phenol-phthalein in ordinary titrations.

Determinations with whey, banana juice, unfiltered extract of cow feces, thick green silage juice, overheated bouillons containing sugar decomposed to a dark brown solution, and vegetable extracts such as that of the potato which had oxidized till it appeared perfectly black in bulk are samples of the material we have handled with errors in P_H which seldom were as great as 0.3 P_H and generally much less.

A consideration of certain broad principles involved in bacteriological studies has led us to believe that in general the order of accuracy which may be attained with these indicators when using simple and rapid procedures is quite adequate for the testing of acid and alkali fermentations, for the study of the effect of P_H upon the stability or decomposition of culture media, for studying the effect of P_H upon the filterability of toxins, enzymes, etc., for determining the effect of P_H upon bacterial metabolism in general and enzyme activity in particular, and for controlling the reaction of solutions during the study of various processes. One of us[11] has already called attention to the inadequacy of the titrimetric method of adjusting the so-called degree of reaction of bacteriological culture media. For adjusting to various P_H values the indicators are quite adequate.

It may be mentioned that many of the criticisms which we have urged against the use of titration methods by the bacteriologist apply with equal force to many tests of the so-called titratable acidity of natural products or extracts thereof. To maintain that the analytical content of acid in some of these solutions can be determined by titration to a given tint of phenolphthalein is untrue. The differences which are determined and which often are of great practical value may frequently be observed with greater clarity by colorimetric P_H determinations. The indicators we have described should therefore be useful in a wide variety of instances.

[11] CLARK, W. M. Journ. Infect. Diseases, 17: 109. 1915.

BOTANY.—*The early European history and the botanical name of the Tree of Heaven,* Ailanthus altissima. WALTER T. SWINGLE, Bureau of Plant Industry.

The story of the first introduction of the Tree of Heaven from China into Europe presents some features of interest which seem to have been overlooked by botanists and arboriculturists of recent times.

INTRODUCTION INTO EUROPE FROM CHINA

The seeds of the Tree of Heaven were first sent from China to the Royal Society of London in 1751 by Pierre d'Incarville, a French Jesuit missionary then residing at Peking. He sent the seeds under the impression that they were secured from the lacquer or varnish tree at Nanking. These seeds were turned over to Philip Miller at Chelsea Gardens and to Philip Carteret Webb at Busbridge near London.

About four years later, on March 18, 1755,[1] Philip Miller, writing to the Royal Society from Chelsea, notes that "the seeds, which were sent to the Royal Society some years ago, for those of the true varnish-tree, by the Jesuits at China, prove to be of this wild sort;" . . . . [Kaempfer's "Fási no ki. *Arbor vernicifera spuria, sylvestris, angustifolia*" = *Rhus succedanea* L.].

John Ellis, afterwards famous for his discovery of the Venus fly trap, *Dionaea muscipula*, sent to the Royal Society on November 8, 1756, an illustrated paper[2] on the lacquer or varnish tree in which he contends that the trees raised at Busbridge and Chelsea from seed sent by Pierre d'Incarville are not the spurious varnish tree of Kaempfer, but a new species of sumac of which he says: "As it has not been yet described, I shall call it . . . . 'Rhus sinense foliis alatis, foliolis oblongis acuminatis, ad basin subrotundis & dentatis.'"[3] He mentions that in Mr. Webb's greenhouse the foliage developed an odor so intensely disagree-

[1] Phil. Trans. Roy. Soc., **49**[1]: 163. 1756.

[2] Phil. Trans. Roy. Soc. **49**[2]: 870–871, pl. 25, fig. 5. 1757.

[3] The Latin term *alatis*, in English *winged*, was used by both Ellis and Miller to denote what we now call pinnate.

able that he frequently got headache and a sickness at the stomach by remaining too long near it. In the summer of 1755 he measured a leaf 3 feet in length and also notes that the tree "throws out a great number of suckers." The base and tip of a leaf are figured and the leaflets show near the base the prominent dentation characteristic of the Tree of Heaven and quite unlike the lacquer tree (*Rhus vernicifera* DC.) or the false lacquer tree (*Rhus succedanea* L.).

Philip Miller replied to Ellis, in a paper published in the Philosophical Transactions two years later,[4] attributing the discrepancies between the leaf characters of Kaempfer's spurious varnish tree, the "*Fási no ki*" of Japan, and the tree grown from the seeds sent from China by Pierre d'Incarville to the difference in situation of the leaves, those of Kaempfer's figure being supposed to be on fruiting branches, while those figured from the tree in Mr. Webb's garden were taken from lower branches. He goes on to cast doubt on the idea of the tree belonging to Rhus, as the seeds he planted "were shaped like a wedge, being thicker on one edge than the other, and not unlike those of the beech-tree."[5]

Ellis, in turn, replied to Miller's criticism in the same number of the *Philosophical Transactions* (pp. 441–456, pls. 17–18), defending his view that the American poison sumac, the Japanese true varnish tree, the Japanese false varnish tree, and the so-called Chinese varnish tree are all different species, and in par-

[4] Phil. Trans. Roy. Soc. 50[1]: 430–440. 1758.

[5] This would indicate that the seeds had been removed from the indehiscent winged fruit. Perhaps this unusual method of treating the seeds may have been to deceive d'Incarville, who supposed he was sending seeds of the lacquer or varnish tree from Nanking when in reality he was sending seeds of the Tree of Heaven, disguised by having been removed from the fruits. The herbarium of d'Incarville, now in the Muséum d'Histoire Naturelle at Paris, contains specimens of *Ailanthus glandulosa* Desf. collected at Peking, with a note: "Cet arbre resemble au Frêne, mais le fleur ny le fruit conviennent point au Frêne, son fruit resemble plus tost à l'Érable." (FRANCHET. *Les plantes du père d'Incarville dans l' herbier du Muséum d'histoire naturelle de Paris.* Bull. Soc. Bot. France, 29: 7. 1882.)

As d'Incarville noted the similarity of these fruits to those of the maple he would doubtless not have been deceived by the *Ailanthus* seeds had they not been taken out of the fruit.

ticular insisting that d'Incarville's supposed China varnish tree was distinct from the Japanese false varnish tree. To substantiate his claim he figured side by side a leaf from d'Incarville's tree grown in Mr. Webb's garden and one of Kaempfer's false varnish tree from the Sherardian herbarium at Oxford. He also examined Kaempfer's specimens in the British Museum. It is but just to say that in this contention Ellis has been fully justified by later botanists.

In neither of his articles did Ellis adopt the Linnaean trivial names introduced in the *Species Plantarum*, published in 1753 (only two to four years before), and so did not publish a name for the Tree of Heaven valid under our present rules of nomenclature.

This appears to have been done for the first time in 1774 when Houttuyn in his *Natuurlyke Historie* reprinted Ellis's Latin diagnosis with the second word set off in parentheses and printed in italics, thus: "Rhus (*Sinense*) Foliis alatis, Foliolis oblongis acuminatis, ad basin subrotundis et dentatis." This is a method of publishing trivial names adopted by Linnaeus in editing the works of travel written by his pupils and also used a few years previously by Philip Miller in the 8th edition of his *Gardeners' Dictionary*, published in 1768. As Ellis had in the meantime adopted the Linnaean nomenclature,[6] it was perfectly proper for Houttuyn to make effective Ellis's vigorously expressed view that the Tree of Heaven constituted a new species of *Rhus* distinct from the Chinese lacquer or varnish tree and from the Japanese false varnish tree.[7]

Owing to the delay in the publication of Ellis's name it was, unfortunately, antedated by *Toxicodendron altissimum*, published by Philip Miller in the eighth edition of his *Gardeners' Dictionary*

[6] In 1768 he wrote an account of the famous Venus fly trap, naming it *Dionaea muscipula*.

[7] The fact that this tree was not listed as a separate species by Houttuyn, but was merely referred to incidentally in his account of *Rhus Vernix* L., does not invalidate this publication, since he refers in the same way on a preceding page to *Rhus succedanea* published by Linnaeus, whom he professes to follow. Furthermore, though he refers to Ellis's species under *Rhus Vernix* L., he could not have meant it as a synonym, since he says it seems to be more nearly related to *Rhus javanica* L., which he describes in another place.

(1768). Without a knowledge of Miller's previous papers it might easily be assumed that this name was applied to the false varnish tree of Kaempfer, which is cited as a synonym after a very short description. However, a closer study shows unmistakably that the name is based on the plant grown in England from the seeds sent by d'Incarville. The specific name *altissimum*, explained in the English paraphrase as the "tallest Poison-tree," is significant, since the wax tree of Japan (the spurious varnish tree of Kaempfer, *Rhus succedanea*) is not taller than the oriental lacquer tree, *Rhus vernicifera* DC., or the American poison sumac, *Rhus Vernix* L., which two latter species were held by Miller to be a single species, *Toxicodendron pinnatis*. The note in the body of the text referring to the new species is still more explicit. It reads as follows: "The tenth sort came from China. This grows to a large size, sending out many branches on every side, which are garnished with very long winged leaves, each leaf having fourteen or sixteen pairs of lobes, which stick close to the midrib; as this has not produced flowers in England, so we are at a loss where to place it, but it is hardy enough to live in the open air in winter. This propagates fast enough by the many suckers sent out from the roots."

There can be no longer any doubt that Miller is basing his new species on the plants grown by him in England. The tall growth, the very long leaves, the abundant suckering, all apply to the Tree of Heaven and not to the Japanese wax tree. Furthermore, his doubts as to the botanical position of the new species, which he puts as the last of the species of *Toxicodendron*, are doubtless based on his memory of the unusual shape of the seeds he planted in 1751 and would not be justified by anything to be found in Kaempfer's description or figures. We must, then, conclude that Miller's *Toxicodendron altissimum* was based on the Tree of Heaven grown in England from seeds sent from China by Pierre d'Incarville in 1751 and that the validity of his species is in no way impaired by his citing of Kaempfer's *Fási no Ki, Arbor vernicifera spuria*, etc., Amoen. Exot. 5: 794, as a synonym, but merely proof that he persisted in his mistaken notion that these two were the same species.

In September, 1782, Friedrich Ehrhart, in the course of a journey in Holland, visited the commercial nurseries of a Mr. Brakel in the outskirts of Utrecht just in front of the Kermis-Waterpoortje. Here he found many rare plants, among them, growing in the open, a tall tree looking something like *Juglans nigra* and having a trunk a foot thick. He named it *Rhus Cacodendron*,[8] basing his diagnosis on leaf characters alone, as he had no flowers or fruits. His article was dated Herrenhausen, 23 Nov., 1782.

In an article dated Herrenhausen, 4 Aug., 1783, published in 1788, Ehrhart reprinted his diagnosis of *Rhus Cacodendron*, which he calls the large-leaved sumac (*"Der grossblättrige Sumac"*),[9] adding that it is a native of North America and occurs in the Dutch gardens and also at Harbke.

In the *Mémoires de l'Académie Royale des Sciences* for 1786, published at Paris in 1788, René Louiche Desfontaines described the Tree of Heaven as *Ailanthus glandulosa*, new genus and new species. This excellent description, accompanied by a good copper plate drawn by L. Freret, is based on a fertile tree growing, presumably at Paris, in the garden of M. le Monnier, first physician-in-ordinary to the king.

In the following year, 1789, William Aiton in his *Hortus Kewensis* recognized *Rhus Cacodendron* as a synonym of *Ailanthus glandulosa* Desf., in spite of Ehrhart's error in assigning a North American origin to his species. Up to within a very few years Desfontaines' name has been almost universally applied to the Tree of Heaven, but recently (in 1912) Ehrhart's older name, *Rhus Cacodendron*, was taken up by Schinz and Thellung and transferred to the genus *Ailanthus*, as *A. Cacodendron*, on the supposition that this was the oldest valid name for this species. As has been shown above, this is not the case, there being at least two older trivial names applied to this species.

[8] EHRHART, FRIEDRICH. *Meine Reise nach der Graffshaft Bentheim, und von da nach Holland, nebst der Retour nach Herrenhausen.* Hannoverisches Magazin, **21**: 225–226 (No. 15, Feb. 21), 1783; reprinted in EHRHART, Beiträge zur Naturkunde, etc. **2**: 111. 1788.

[9] EHRHART, FRIEDRICH. *Bestimmung einiger Bäume und Sträuche aus unsern Lustgebüschen.* Beiträge zur Naturkunde, **3**: 20. 1788.

The oldest valid name applied to the Tree of Heaven was *Toxicodendron altissimum;* consequently its synonomy becomes as follows:[10]

Ailanthus altissima (Miller) Swingle, comb. nov.
Toxicodendron Altissimum Miller, Gard. Dict., ed. 8. 1768.
Rhus Sinense Ellis; Houttuyn, Natuur. Hist., II. **2:** 212. 1774.
Rhus Cacodendron Ehrhart, Hannov. Mag., **21:** 225–226, Feb., 1783; Beiträge, **2:** 111. 1788.
Ailanthus glandulosa Desf. Mém. Acad. Sci. Paris, **1786:** 265, pl. 8. 1788; L'Heritier, Stirp. Nov., 179–181, pl. 84. 1791.
Ailanthus procera Salisbury, Prodr. 171. 1796.
Pongelion glandulosum Pierre, Fl. Cochinchin., **4:** text pl. 294. 1893.
Ailanthus Cacodendron Schinz & Thellung, Mém. Soc. Sci. Nat. Cherbourg, **38:** 679. 1912.

In spite of the derivation of the generic name from the native name of a tree growing in Amboyna, *Ailanthus* is not based upon the Amboyna species described by Rumphius but on *A. glandulosa,* as Desfontaines says that the *Arbor coeli*[11] of Rumphius *seems* to belong to his genus, which of course makes it clear that he does not definitely include it.

ORIGIN OF THE NAME "TREE OF HEAVEN"

The common name of this tree also has a curious history. At first it was supposed to be the Chinese varnish tree, because seeds had been sent from China under that name by d'Incarville. When Desfontaines constituted a new genus for this Chinese species he named it *Ailanthus* from the native name *Aylanto* of a tree growing in Amboyna, as he thought the Amboyna tree

[10] There is no warrant for using the generic name *Pongelion* Adans., 1763, or *Pongelium* Scopoli, 1777, for this tree and its congeners, since no species were published under either name until 1893, when Pierre resuscitated *Pongelium* under the mistaken idea that it was established before *Ailanthus* of Desfontaines.

[11] "*Il* [*Ailanthus glandulosa*] est originaire de la Chine, & *l'arbor coeli* de Rumphius, *hort. amboin.* que les Indiens appelent *ailanthe,* dans leur langue, est une espèce qui nous paroît appartenir au genre que nous venons de décrire; c'est pourquoi nous avous conservé cette dénomination pour nom générique." (Desfontaines. *Mémoire sur un nouveau genre d'arbre Ailanthus glandulosa. L'Ailanthe glanduleux.* Mém. Acad. Sci. Paris, **1786:** 271. 1788.

probably belonged to the same genus. Rumphius, in his *Herbarium Amboinense*, says:[12] "*Arbor coeli* is called in Malay *Caju langit*, in Amboyna, *Aylanto*, that is, heaven-tree,[13] as if they would accuse it of lacerating the heaven because of its height." Rumphius had previously said it was the tallest tree known to him in Amboyna.

Rumphius' species (*Ailanthus Pongelion* Gmel., figured in Herb. Amboin 3, pl. 132) was at first confounded with the Chinese tree and probably this led to the transfer of the Malayan name, "tree of heaven," to the Chinese species. Even without this confusion of the species, the name "tree of heaven" could easily be formed by a mere translation of the generic name.

Curiously enough, although the modern Chinese name around Peking is *Ch'ou Ch'un* 臭 椿 or stinking ch'un (in contrast to *Hsiang Ch'un* 香 椿 or fragrant ch'un, *Cedrela sinensis* Juss.), it is known to the Chinese poets of older times as *Shên shu* 神 樹 or God's tree. It is interesting to note that this old Chinese epithet is exactly translated in the German *Götterbaum*. Su Shih (or Su Tung-po), 1036–1101 A. D., a famous scholar of the Sung dynasty, wrote a stanza beginning, "Since ancient times it was called God's tree," and goes on to lament the departure of the spirit formerly supposed to dwell within this tree. (Imperial Encyclopedia, T'u shu chi ch'êng, Science, Vegetable Kingdom, Bk. 253). In the Book of History and in other ancient Chinese works this plant is called *Ch'u* 樗 , which name is still used in some parts of China at the present time.

THE TREE OF HEAVEN IN THE UNITED STATES

According to A. J. Downing, the Tree of Heaven was introduced directly from China into Rhode Island under the name

[12] **3**: 206. According to the Century Dictionary (1913 Edition, **1**: 121) the native name *aylanto* is apparently derived from *ai lanit*, a Moluccan form of the Malayan *kāyu langit*, tree of the sky.

[13] Possibly this ties up with the "heaven-tree," said by James H. Murray (New English Dict., **5**: 177) to be a "mythical tree, which figures in some Malay and Polynesian beliefs, as reaching from the under-world to the earth, or from earth to heaven."

tillou.[14] Sprouts from the roots of these original trees were used to propagate the species which was common in the nurseries of this country as early as 1841, when Downing published the first edition of his famous work on landscape gardening.[15]

Ailanthus altissima grows like a weed and is in fact a common weed in the towns and villages of the northern United States. Even in the outskirts of New York, Washington, and other large cities it is spreading rapidly over waste land by means of its abundant root sprouts. It is undeniably a handsome tree and grows most luxuriantly even in cities where smoke and dust harm most other trees; furthermore, its foliage is almost immune to attack by insects. The leaves fall suddenly in autumn after the first frosts, exposing the smooth-barked branches which are destitute of small lateral twigs.

Experts have prized the wood of the Tree of Heaven very highly both for fuel and for cabinet-making. They have ranked its wood with that of the white oak, black walnut, and birch for fuel, and considered it as having few superiors among woods in temperate regions as material for the cabinet-maker's use. Its heavy, strong, clear, light-yellow wood does not shrink or warp in drying and although coarse grained it takes a fine polish. It is said to produce wood, even on poor soil, more than twice as fast as any native tree having wood of anything like the same fuel value.[16]

The greatest drawback to this tree is the disagreeable odor of the male flowers, probably carried by the pollen, which is said also to cause irritation of the throat and eyes, to some persons at least. If only fertile trees are propagated, which is easily done by taking suckers from seed-bearing trees, this drawback is in large part overcome, for the fertile trees, although usually

[14] This name cannot at present be traced; it is perhaps a South Chinese name, as the China merchants of the eighteenth and early nineteenth centuries traded chiefly with Canton.

[15] Downing, A. J. *A treatise on the theory and practice of landscape gardening*, Ed. 1, p. 174. 1841.

[16] [Stiles, William Augustus]. *The Ailanthus*, [Editorial] in Garden and Forest, **11**: 385–386. 1888.

having fertile stamens, do not produce nearly so much pollen as the male trees.

Other drawbacks to this species as an ornamental tree are its habit of sprouting profusely from the roots and the fact that its leaves and twigs are malodorous if rubbed or bruised even slightly. Ailanthus trees, if cut off after they are once well established, send up astonishingly vigorous shoots that sometimes grow 12 to 15 feet high in a single season and bear leaves 4 or 5 feet long. Because of this they are sometimes used as a screen, being cut to the ground every year.

AILANTHUS A FOOD FOR WILD SILK WORMS

In China a silk worm, *Attacus cynthia* or *Philosamia cynthia*, eeds on the leaves of *Ailanthus* and produces a very durable kind of silk, similar to shantung or pongee. An account of the wild silk worms of China was published in 1777 by the French Jesuit missionary Martial Cibot.[17] He noted this tree under its Chinese name, *Ch'ou ch'un* (tcheou-tchun), as one of the three species on which the Chinese wild silk worm feeds. This Ailanthus silk worm has been introduced into Europe and America and has become naturalized in the eastern United States. It would be hard to find a plant capable of producing a larger bulk of leaves than the Tree of Heaven, and as these so-called wild silk worms feed out of doors and can endure cold and even wet weather, it would seem worth while to experiment in raising them in this country for silk production.

[17] CIBOT, PIERRE MARTIAL. *Sur les vers à soie sauvages.* Mém. concernant l'hist. les sciences etc. des Chinois, **2**: 575–598. Paris, 1777

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

PHYSICS.—*Sensitivity and magnetic shielding tests of a Thomson galvanometer for use in radiometry.* W. W. COBLENTZ. Bureau of Standards Scientific Paper No. 282 (Bull. Bur. Stds., **13**: 423–446). 1916.

The present paper gives the results of an investigation of the force exerted by various galvanometer coils when operated under standard conditions. Some of the coils were wound according to theoretical requirements, while others were wound empirically. Numerical data are given relating to coils having various resistances.

A simple coil is described, wound with a single size of wire (No. 28 B & S) which is as efficient as a compound coil wound upon the same mandrel but in three sections of graded wire.

A 9-ohm coil of graded wire is described which is very efficient and is well adapted for use with the bismuth-silver thermopiles previously described.

A comparison is made of various astatic magnet systems, and data are given showing the importance of using small mirrors, in order to increase the sensitivity.

Experiments in shielding the galvanometer from external magnetic disturbances are described. Various shields are described consisting of laminated cylinders made from transformer iron and solid cylindrical shells cut from wrought iron gas pipe. By embedding the galvanometer coils in blocks of Swedish iron which are surrounded by cylindrical shells of transformer iron and of wrought iron, the effect of external magnetic perturbations upon the astatic needle system is easily reduced to 1/2000 of its original value. This embedding of the coils also reduces the air space; the resultant elimination of convection currents greatly improves the steadiness of the needle system.

Experiments on a vacuum galvanometer, in which a sensitivity was attained which is more than 10-fold that used in the writer's previous work on stellar radiation, are described. W. W. C.

METROLOGY.—*Report of the tenth annual Conference on Weights and Measures, May 25–28, 1915.* BUREAU OF STANDARDS. Bur. Stds. Special Publication. Pp. 254. 1916.

The report is a record of the proceedings of the Conference, which is composed of State and local weights and measures officials and weights and measures manufacturers from various parts of the United States.

The report consists of the papers presented and of the general record of the conference proceedings. It includes short reports of about twenty-five State delegates on the progress made in the enforcement of local laws during the year and a report of the Bureau of Standards showing the progress made in the track scale tests for States, railroads, and industrial corporations; papers on the methods of testing track scales, on the construction of automatic scales, and on the meaning and effect of the standard barrel law recently enacted by Congress; a general discussion of legislation pending in Congress and of the proper limits for suggested legislation. The tolerances and specifications for commercial weighing and measuring apparatus and a model State law on weights and measures adopted by the conference are given in full in the appendix. L. A. F.

ELECTRO-CHEMISTRY.—*The volume effect in the silver voltameter.* E. B. ROSA and G. W. VINAL. Bureau of Standards Scientific Paper No. 283 (Bull. Bur. Stds. **13**: 447–457). 1916.

Some years ago the Bureau discovered that the silver deposits in large size voltameters were consistently heavier than the deposits in small voltameters which were used in series with them. The cause of this effect was attributed to impurities in the solution, but this explanation was not accepted by all the observers who have worked with the voltameter. Because the evidence rested principally on the results with the porous cup form of voltameter, Jaeger and von Steinwehr thought that the effect was due to the porous cup. Richards, on the contrary, thought that the greater surface of the large cathodes permitted greater inclusions and therefore the deposit appeared heavier. The recent experiments of Vinal and Bovard have shown that Richards'

theory is not correct, but some further experiments were necessary to answer Jaeger and von Steinwehr's contention.

The authors have analyzed all of their former observations with reference to the volume of the electrolyte, the weight of the deposit, and the purity of the solution. They have also made some further experiments with especially impure solutions and with other forms of the voltameter than the porous cup form. All of these observations have been treated by statistical methods, and the authors show, first, that the volume effect is not confined to the porous cup form of voltameter, but that it is common to all forms of voltameter, and, sec nd, that it is caused by impurities in the electrolyte. The authors give a theory of the mechanism of the effect, and they believe that the evidence proves conclusively that the effect is a valuable criterion for the purity of the silver nitrate. G. W. V.

PALEONTOLOGY.—*Cambrian trilobites.* CHARLES D. WALCOTT. Smithsonian Misc. Coll., **64**: No. 3, 1916.

The purpose of this paper is to afford data to aid in clearing up some of the problems of formations of the Appalachian region by a careful comparison of portions of their contained faunas with those of the Mississippi Valley, the Cordilleras, and other localities. No thorough study and comparison of many genera of the Cambrian faunas has been made, though collections from many outcrops have been in the writer's possession for years, awaiting the opportunity to make these studies so necessary in his work on the Cambrian trilobites.

The paper is illustrated with fifteen plates, containing 280 figures of trilobites. Two new families are proposed, Menomonidae and Norwoodidae, and seven new genera: *Menomonia, Millardia, Dresbachia, Norwoodia, Saratogia, Vanuxemella,* and *Hanburia;* 46 new species and three new varieties are described and figured, with 19 earlier described species and several genera. One of the marked features of the paper is the description of a number of genera of the order Proparia: *Menomonia, Millardia, Dresbachia,* and *Norwoodia.* These, the writer says, taken in connection with the genus *Burlingia,* described in a previous paper [*Cambrian trilobites.* Smithsonian Misc. Coll., **53**: No. 2, p. 14. 1908.] establish the existence of a strong group of the order in Cambrian time.

The stratigraphic position of the Weeks formation is changed from Middle to Upper Cambrian, and the problem of whether the Conasauga

formation of the Coosa Valley and adjoining areas shall be restricted to the Upper Cambrian, and the Middle Cambrian beds there given a formation name, is left for further detailed study.

The discussion and comparison of the *Crepicephalus* group of trilobites is particularly interesting, including a comparison of 17 different species, 10 of them new species, 3 new varieties, and two undetermined species. The five plates of illustrations of this large trilobite also present many new and interesting features of the animal, now so long extinct. G. R. B.

GEOLOGY.—*The Caddo oil and gas field, Louisiana and Texas.* GEORGE C. MATSON. U. S. Geologicl Survey Bulletin 619. Pp. 62, with map, sections, and illustrations. 1916.

This bulletin contains a description of the physiography, geology of the Cretaceous, Tertiary, and Quaternary systems, and the structure of the rocks in the Caddo oil and gas field. It also discusses relations of oil and gas and the possible extensions of the Caddo oil field. R. W. S.

GEOLOGY.—*Ground water in San Joaquin Valley, California.* W. C. MENDENHALL, R. B. DOLE, and HERMAN STABLER. U. S. Geological Survey Water-Supply Paper No. 398. Pp. 310, 5 plates and 4 figures. 1916.

This report outlines the geography and geology of the valley, the character of the soils, and the availability of the surface waters, and describes in detail the occurrence, utilization, and quality of the ground waters, especially in reference to their availability for irrigation, boiler supply, and domestic use. The great value of the agricultural products and the lack of sufficient surface water in this valley have brought about unusual development of ground water resources. Nearly every phase of practical irrigation is illustrated, including flood, deep-ditch, and subterranean irrigation, the utilization of deep waters, the use of steam and gas engines and electric motors for power, the disastrous rise of alkali, the effect of alkali on growing plants, and the application of strongly mineralized waters. Ground water of good quality can be pumped at moderate expense throughout the east side of the valley, but the level of the ground water on the west side is much deeper and the mineral content of the water is much greater; yet neither its cost nor its quality will prevent its ultimate use in many parts of

the west side. The axis of the valley includes a long narrow area yielding flowing water that ranges widely in chemical character at different depths and in different places. The report as a whole exemplifies geologic, engineering, and chemical methods for reconnaissance of ground water resources in large areas. It includes records of more than 8,500 wells, 500 assays and analyses, and 55 tests of pumping plants. R. B. D.

GEOLOGY.—*Retreat of Barry Glacier, Port Wells, Prince William Sound, Alaska, between 1910 and 1914.* B. L. JOHNSON. U. S. Geological Survey Professional Paper 98–C. Pp. 5, with illustrations. 1916.

This short paper gives the linear retreat of the Barry glacier for a number of years and 6 photographs taken in different years and from different points of view illustrating the face of the glacier during different stages of retreat. R. W. S.

GEOLOGY.—*Ground water in the Hartford, Stamford, Salisbury, Willimantic, and Saybrook areas, Connecticut.* HERBERT E. GREGORY and ARTHUR J. ELLIS. U. S. Geological Survey Water-Supply Paper No. 374. Pp. 146, with maps, sections, and views. 1916.

The areas covered by this report represent the typical geologic conditions of Connecticut. The Hartford area, in the Connecticut River Valley, is underlain by Triassic sediments and lavas; the Stamford area, in the southwest corner of the State, is underlain by crystalline rocks; the Salisbury area, in the northwest corner of the State, has its lowlands underlain by Cambrian or Ordovician limestone; the Willimantic area, in the eastern highlands, is underlain by metamorphic rocks of various types on which a highly varied topography has been developed; the Saybrook area, at the mouth of Connecticut River, is low and comparatively flat and the presence of salt water is a feature of ground water problems.

The chief water-bearing formation in all of these areas is the glacial drift overlying the bedrocks. It includes unstratified drift, or till, and stratified drift, or glacial outwash. The latter occurs principally as valley fill and in the Connecticut Valley attains a thickness of more than a hundred feet. Unstratified drift is the principal source of private domestic water supplies, which are generally obtained from wells less

than 30 feet deep. Municipal supplies could be developed from the stratified drift in the Connecticut Valley by sinking gangs of driven wells similar to those successfully used at Brookline, Mass., Brooklyn, N. Y., and Plainfield, N. J., which are described in the report.

The bedrocks are practically impervious, but they are intensely fractured, and contain numerous water-bearing joints. Wells drilled to depths of 200 or 300 feet rarely fail to intercept a sufficient number of these joints to furnish supplies of water adequate for domestic use.

A. J. E.

GEOLOGY.—*Experiments on the extraction of potash from Wyomingite.* R. C. WELLS. U. S. Geological Survey Professional Paper 98–D. Pp. 4. 1916.

This paper describes investigations made in the chemical laboratory of the U. S. Geological Survey to determine the possibility of extracting potash from Wyomingite and lava occurring extensively in the Leucite Hills, Sweetwater County, Wyoming. While all the experiments described can not be considered as suggestions of commercial possibilities, a record of them may save much repetition of preliminary investigation on the part of private investigators.

R. W. S.

GEOLOGY.—*Geology and coal resources of Castle Valley, in Carbon, Emery, and Sevier Counties, Utah.* CHARLES T. LUPTON. U. S. Geological Survey Bulletin No. 628. Pp. 86, with 12 plates and 1 figure. 1916.

This report describes the geology and coal resources of Castle Valley, a belt of country 10 to 20 miles wide and 80 miles long lying between San Rafael Swell and Wasatch Plateau in central Utah. It includes also general descriptions and sections of those formations outcropping from the interior of the Swell to the top of the Plateau, a stratigraphic distance of more than 11,000 feet. The rocks exposed range from Carboniferous to Quaternary in age.

The Ferron sandstone member of the Mancos shale, which varies greatly in thickness and character, is described and indicated on the maps. At the northeast end of the field it is about 75 feet thick and consists mainly of shaly sandstone containing concretions. It thickens gradually, reaching a maximum of about 800 feet of sandstone, shale, and coal beds near the southwest end of the area described. This sandstone, in the northern part of Castle Valley, is believed to repre-

sent the feather edge of a series of coal-bearing rocks in the lower part of the Colorado group recognized in northern Arizona, southwestern, west-central, and northern Utah, and southwestern Wyoming.

A large part of the report consists of a description of the coal, which is bituminous and occurs principally in the above mentioned sandstone. A little coal is present in the Dakota sandstone but is not economically important. A large amount of coal is contained in the Mesaverde formation in Wasatch Plateau, but it was not extensively studied. C. T. L.

GEOLOGY.—*The physical conditions and age indicated by the flora of the Alum Bluff formation.* E. W. BERRY. U. S. Geological Survey Professional Paper 98–E. Pp. 18, with illustrations. 1916.

This paper describes a small flora from the Alum Bluff formation in Liberty County, Florida. This flora represents a horizon hitherto unrepresented paleobotanically in southeastern North America. It is concluded that the Alum Bluff formation as a whole is a predominantly shallow water deposit of clays and sands, and that the flora preserved at Alum Bluff records the last phase of sedimentation before the area emerged from the sea. The most profound break in Tertiary sedimentation in the southeastern United States is represented by the unconformity at the top of the Alum Bluff formation. R. W. S.

GEOLOGY.—*The Chisana-White River district, Alaska.* STEPHEN R. CAPPS. U. S. Geological Survey Bull. 630. Pp. 126, with maps, sections, and views. 1916.

The Chisana-White River district comprises that portion of the White River basin which lies west of the international boundary and the headward portion of the Chisana River basin east of that river and south of the north front of the Nutzotin Mountains. The oldest rocks of the district are basic lavas and pyroclastics with a considerable amount of black shale of Devonian age. The next succeeding system, the Carboniferous, comprises a great thickness of interbedded lavas, tuffs, agglomerates, and breccias, containing very little sedimentary material. Upon these lies a bed of massive limestone, associated with thin-bedded limestones and shales. Above the limestones and shales is a great thickness of lavas and pyroclastic rocks similar to those mentioned, again interrupted by other massive limestones. These in turn are succeeded by other bedded basic lava flows, which form the highest part of the Carboniferous system recognized in this district.

The rocks next younger are massive limestones carrying Triassic fossils. In the Nutzotin Mountains there are banded slates and graywackes, scantily fossiliferous, which may be in part Triassic.

Shales and graywackes of Jurassic age have been recognized in the region, but their upper and lower limits were not determined. Shales and graywackes, carrying Lower Cretaceous fossils, lie immediately above the Jurassic beds, without any observed stratigraphic break.

Tertiary sediments are represented by small, detached areas of shale, sandstone, conglomerate, and tuff, with minor amounts of lignite. Certain old but unconsolidated gravels are also probably of Tertiary age. The extrusion of widespread lava flows was also begun in Tertiary time and has continued intermittently ever since, so that it is difficult to separate the Tertiary from the Quaternary lavas.

Quaternary deposits are present in considerable variety and abundance. The oldest consist of glacial till and outwash gravels interbedded with lava flows, representing a stage of glaciation much earlier than the last notable ice advance. These older glacial deposits are overlain by extensive lava flows. During their last great advance the glaciers left deposits of morainal material scattered throughout the district. Large deposits of outwash gravels were laid down during the retreat of the ice and are still accumulating in the valleys of the glacier-fed streams. Accumulations of talus, peat, and muck, with some volcanic ash, and the products of normal stream deposition make up the postglacial materials in the areas not now receiving glacial and glacio-fluvial deposits. A. H. B.

TECHNOLOGY.—*The properties of some European plastic fire clays.* A. V. Bleininger and H. G. Schurecht. Bureau of Standards Technologic Paper No. 79. Pp. 34. 1916.

The properties of five well known European plastic fire clays, largely used for glass pots, graphite crucibles, etc., have been studied for the purpose of securing data, making possible a comparison with similar American clays. Such properties as the content of shrinkage and pore water, drying shrinkage, fineness of grain, rate of drying, mechanical strength in the dry state, rate of vitrification, final softening temperature, and the chemical composition were determined.

From the results obtained it was shown that these famous European clays do not differ radically from similar materials found in this country but that the same, or possibly superior, results can be obtained with mixtures of known American clays. A. V. B.

TECHNOLOGY.—*Further data on the oxidation of automobile cylinder oils.* C. E. WATERS. Bureau of Standards Technologic Paper No. 73. Pp. 20. 1916.

In continuation of work already published by the Bureau of Standards, as well as in the Journal of Industrial and Engineering Chemistry, a study was made of the rate of oxidation of three automobile cylinder oils when exposed to sunlight and air. This was done by determining the increase in weight and in acidity at intervals during a period of 438 hours exposure. The accompanying changes in the carbonization values were also determined. The general result was that there is a gradual lessening of the rate at which the weight increases, and at the same time the formation of acid and the carbonization value increase more and more rapidly.

The Maumené numbers of the oils increased greatly as a result of oxidation, while there was a marked drop in the iodine numbers. After oxidation the oils showed a much greater tendency than before to emulsify when agitated with water. Filtration through animal charcoal removed, to a certain extent, the substances that caused this tendency and that raised the carbonization values.

When the three oils used in the work above, and eight others, were heated to 250°C. for periods ranging from one to seven hours, the formation of carbonized matter proceeded at a rapidly increasing rate. The same was true of the eleven oils when heated for three hours at various temperatures from 230° to 280°C. It was found that in both cases, the greater the carbonization value at first, the more rapidly did it increase as the temperature was raised or the time of heating extended. In other words, an oil which had a low carbonization value if heated to 250° for two or three hours, and an oil showing a somewhat higher value under the same conditions, will be farther and farther apart as the conditions become more strenuous. This being so, it is unnecessary to prolong greatly the time of heating in routine testing.

The need of extreme care in taking and preserving samples, as well as in testing them, was emphasized, because the presence of rust particles or other extraneous matter increases the amount of carbonization.

In conclusion it is shown that the carbonization value is independent of the flash and fire points and of the evaporation loss on heating.

C. E. W.

REFERENCES

Under this heading it is proposed to include, by author, title, and citation, references to all scientific papers published in or emanating from Washington. It is requested that authors cooperate with the editors by submitting titles promptly, following the style used below. These references are not intended to replace the more extended abstracts published elsewhere in this JOURNAL.

TERRESTRIAL MAGNETISM

AULT, J. P. *Magnetic declinations and chart corrections obtained by the "Carnegie" from Dutch Harbor, Alaska, to Lyttelton, New Zealand, August to November, 1915.* J. Terr. Mag., **21**: 15–18. 1916.

BAUER, L. A. *On possible planetary magnetic effects.* Phys. Rev., (2) **7**: 500. 1916.

BAUER, L. A. *Solar radiation and terrestrial magnetism.* Phys. Rev., (2) **6**: 505–506. 1915.

BAUER, L. A. *Concomitant changes in terrestrial magnetism and solar radiation.* Proc. Nat. Acad. Sci., **2**: 24–27. 1916.

BAUER, L. A. *Solar radiation and terrestrial magnetism.* J. Terr. Mag., **20**: 143–158. 1915.

BAUER, L. A., and FLEMING, J. A. *Researches of the Department of Terrestrial Magnetism. Vol. II. Land magnetic observations, 1911–1913, and reports on special researches.* Carnegie Institution of Washington Publication No. 175. 1915.

BAUER, L. A. *The earth's magnetism.* Ann. Rep. Smithsonian Institution for 1913, pp. 195–222. 1914.

HAZARD, D. L. *Distribution of the magnetic declination in the United States for January 1, 1915, with isogonic chart and secular change tables.* U. S. Coast and Geodetic Survey Special Publication No. 33, Serial No. 18. 1915.

HAZARD, D. L. *Results of observations made at the United States Coast and Geodetic Survey Magnetic Observatory at Cheltenham, Maryland, 1913 and 1914.* U. S. Coast and Geodetic Survey Serial Publication No. 19. 1915.

HAZARD, D. L. *Results of observations made at the United States Coast and Geodetic Survey Magnetic Observatory near Honolulu, 1913 and 1914.* U. S. Coast and Geodetic Survey Serial Publication No. 21. 1916.

HAZARD, D. L. *Results of observations made at the United States Coast and Geodetic Survey Magnetic Observatory near Tucson, Arizona, 1913 and 1914.* U. S. Coast and Geodetic Survey Serial Publication No. 23. 1916.

PHYSICS

ABBOT, C. G. *Radiation and atmosphere.* Phys. Rev., (2) **6**: 504–505. 1915.

ABBOT, C. G., and ALDRICH, L. B. *The pyranometer: an instrument for measuring sky radiation.* Proc. Nat. Acad. Sci., **2**: 333–335. 1916.

AUSTIN, L. W. *Quantitative experiments with the audion.* J. Wash. Acad. Sci., **6**: 81–84. 1916.

AUSTIN, L. W. *Resistance of radiotelegraphic antennas.* J. Wash. Acad. Sci., **5**: 525–526. 1915; Bur. Stds. Sci. Paper No. 257 (Bull. Bur. Stds., **12**: 465–468). 1915.

BATES, FREDERICK, and JACKSON, RICHARD F. *The constants of the quartz-wedge saccharimeter and the specific rotation of sucrose. Part I: The constants for the 26-gram normal weight.* J. Wash. Acad. Sci., **6**: 25–31. 1916; Bur. Stds. Sci. Paper No. 268 (Bull. Bur. Stds., **13**: 67–128). 1916.

BAUER, L. A. *General results of the work in atmospheric electricity aboard the "Carnegie," 1909–1914.* Proc. Amer. Phil. Soc., **54**: 14–17. 1915.

BEARCE, H. W., and PEFFER, E. L. *Density and thermal expansion of American petroleum oils.* Bur. Stds. Tech. Paper No. 77. Pp. 26. 1916.

BINGHAM, E. C. *Plastic flow.* J. Wash. Acad. Sci., **6**: 177–179. 1916; Bur. Stds. Sci. Paper No. 278 (Bull. Bur. Stds., **13**: 309–353). 1916.

BRIGGS, LYMAN J. *A new method of measuring gravity at sea.* Proc. Nat. Acad. Sci., **2**: 399–407. 1916.

BUCKINGHAM, E. *The principle of similitude.* Nature, **96**: 396–397. 1915.

BUCKINGHAM, E. *Notes on the dimensional theory of wind tunnel experiments.* Smithsonian Miscellaneous Coll., vol. 62, No. 4. 1915.

BUCKINGHAM, E. *The theory of the Pitot and Venturi tubes.* First Ann. Rep. Nat. Advisory Comm. for Aeronautics. 1915.

BUREAU OF STANDARDS. *Standards for electric service.* 1st ed. Circular No. 56. Pp. 262. 1916.

BUREAU OF STANDARDS. *Electric units and standards.* Circular No. 60. Pp. 68. 1916.

BURGESS, G. K., and FOOTE, P. D. *Characteristics of radiation pyrometers.* Bur. Stds. Sci. Paper No. 250 (Bull. Bur. Stds., **12**: 91–178). 1915.

BURGESS, G. K., and FOOTE, P. D. *Thermometry, pyrometry, and heat conductivity.* Standard Handbook for Electrical Engineers. 1915.

BURGESS, G. K., and WALTENBERG, R. G. *Further experiments on the volatilization of platinum.* J. Wash. Acad. Sci., **6**: 365–366. 1916; Bur. Stds. Sci. Paper No. 280 (Bull. Bur. Stds., **13**: 365–373). 1916; J. Ind. and Eng. Chem., **8**: 487. 1916.

BURNS, KEIVEN, and MEGGERS, W. F *Interference measurements of wave lengths in the iron spectrum (2851A–3701A), with notes on comparisons of lengths of light waves by interference methods, and some wave lengths in the spectrum of neon gas.* Bur. Stds. Sci. Paper No. 251 (Bull. Bur. Stds., **12**: 179–205). 1915.

BURNS, KEIVEN, MEGGERS, W. F., and MERRILL, PAUL W. *Interference measurements of the wave lengths in the iron spectrum (3233A–6750A).* Bur. Stds. Sci. Paper No. 274 (Bull. Bur. Stds., **13**: 245–272). 1916.

BURROWS, CHAS. W. *Correlation of the magnetic and mechanical properties of steel.* Bur. Stds. Sci. Paper No. 272 (Bull. Bur. Stds., **13**: 173–208). 1916.

COBLENTZ, W. W. *The constants of radiation of a black body.* Phys. Rev., (2) **7**: 694–695. 1916.

COBLENTZ, W. W. *Present status of the determination of the constant of total radiation from a black body.* Bur. Stds. Sci. Paper No. 262 (Bull. Bur. Stds., **12**: 553–582). 1916.

COBLENTZ, W. W. *Sensitivity and magnetic shielding tests of a Thomson galvanometer for use in radiometry.* Bur. Stds. Sci. Paper No. 282 (Bull. Bur. Stds., **13**: 423–446). 1916.

COBLENTZ, W. W. *Constants of spectral radiation of a uniformly heated inclosure or so-called black body, II.* J. Wash. Acad. Sci., **6**: 418. 1916; Bur. Stds. Sci. Paper No. 284 (Bull. Bur. Stds., **13**: 459–477). 1916.

COBLENTZ, W. W. *Glasses for protecting the eyes from infra-red rays.* J. Franklin Inst., **179**: 579–580. 1915.

COBLENTZ, W. W. *The physical photometer in theory and practice.* J. Franklin Inst., **180**: 335–348. 1915; **181**: 233–241. 1916.

COBLENTZ, W. W., and EMERSON, W. B. *Studies of instruments for measuring radiant energy in absolute value: an absolute thermopile.* Bur. Stds. Sci. Paper No. 261 (Bull. Bur. Stds., **12**: 503–557). 1916.

COBLENTZ, W. W., and EMERSON, W. B. *The coefficient of total radiation of a uniformly heated enclosure.* Phys. Rev., (2) **7**: 693–694. 1916.

COBLENTZ, W. W., and EMERSON, W. B. *Distribution of energy in the visible spectrum of an acetylene flame.* Bur. Stds. Sci. Paper No. 279 (Bull. Bur. Stds., **13**: 355–364). 1916.

CRITTENDEN, E. C., and RICHTMYER, F. K. *An "average eye" for heterochromatic photometry and a comparison of a flicker and an equality of brightness photometer.* Trans. Illuminating Eng. Soc., **11**: 331–356. 1916.

CURTIS, H. L. *The volume resistivity and surface resistivity of insulators.* Gen. Elec. Rev., **18**: 996–1001. 1915.

CURTIS, H. L. *An alternating current method of measuring mutual inductance.* Phys. Rev., (2) **7**: 692–693. 1916; Elec. World, **68**: 91–92. 1916.

DELLINGER, J. H. *The calculation of Planck's constant C_2.* Phys. Rev., (2) **7**: 687–688. 1916; J. Wash. Acad. Sci., **6**: 472. 1916; Bur. Stds. Sci. Paper No. 287 (Bull. Bur. Stds., **13**: 535–545). 1916.

FOOTE, PAUL D. *The "center of gravity" and "effective wave length" of transmission pyrometer color screens.* J. Wash. Acad. Sci., **5**: 526–530. 1915.

FOOTE, PAUL D. *"Center of gravity" and "effective wave length" of transmission pyrometer color screens, and the extrapolation of the high temperature scale.* Bur. Stds. Sci. Paper No. 260 (Bull. Bur. Stds., **12**: 483–501). 1915.

FOOTE, PAUL D. *The relation between color temperature, apparent temperature, true temperature, and monochromatic emissivity of radiating materials.* J. Wash. Acad. Sci., **6**: 317–323. 1916.

FOOTE, PAUL D. *Luminosity and temperature of metals.* J. Wash. Acad. Sci., **6**: 323–326. 1916.

FOOTE, PAUL D. *The illumination from a radiating disk.* Bur. Stds. Sci. Paper No. 263 (Bull. Bur. Stds., **12**: 583–586). 1916.

FOOTE, PAUL D. *A new relation derived from Planck's law.* Phys. Rev., (2) **7**: 224–225. 1916; Bur. Stds. Sci. Paper No. 259 (Bull. Bur. Stds., **12**: 479–482). 1915.

FOOTE, PAUL D., and FAIRCHILD, C. O. *A misconception of the criterion for gray body radiation.* J. Wash. Acad. Sci., **6**: 193–197. 1916.

GRAY, A. W., SWEET, D. H., SCHAD, L. W. *Some effects of magnetization on the length of a 35.25 per cent nickel steel.* Phys. Rev., (2) **7**: 684. 1916.

GRAY, A. W., SWEET, D. H., SCHAD, L. W. *American nickel steels of low thermal expansivity.* Phys. Rev., (2) **7**: 685. 1916.

GRAY, A. W. *Protected thermoelements.* Bur. Stds. Sci. Paper No. 276 (Bull. Bur. Stds., **13**: 283–285). 1916.

GROVER, FREDERICK W. *The calculation of the maximum force between two parallel, coaxial, circular currents.* J. Wash. Acad. Sci., **5**: 456–458. 1915; Bur. Stds. Sci. Paper No. 255 (Bull. Bur. Stds., **12**: 317–373). 1915.

HERSCHEL, WINSLOW H. *Determining the equation of a curve.* Bull. Soc. Promotion Eng. Education, June, 1915, p. 33. 1915.

HERSCHEL, WINSLOW H. *The Pitot tube and other anemometers for aeroplanes.* First Ann. Rep. Nat. Advisory Com. for Aeron., Report 2, part 1, p. 79. 1915.

HERSCHEL, WINSLOW H. *Most economical vacuum for steam turbines.* Power, June 1, 1915, p. 744. 1915.

HERSCHEL, WINSLOW H. *Correlation between tensile and bending tests of cast iron.* Tech. Monthly and Harvard Eng. Journ., Feb., 1916.

HERSCHEL, WINSLOW H. *Quantitative test for resistance of lubricating oils to emulsification* Power, **43**: 485. 1916; Oil, Paint and Drug Reporter, April 17, 1916, p. 36 R; Proc. Amer. Soc. Test. Materials. 1916.

HERSCHEL, WINSLOW H. *The lubricating value of oils, with remarks on the Baumé hydrometer.* Oil, Paint, and Drug Reporter, April 17, 1916, p. 36 R. 1916.

HERSCHEL, WINSLOW H. *Remarks on efflux viscosimeters.* J. Wash. Acad. Sci., **6**: 155. 1916.

HERSEY, M. D. *The present work of the Bureau of Standards.* Tech. Monthly and Harvard Eng. Journ., **2**: 4–10. 1915.

HERSEY, M. D. *Aneroid barometers.* Phys. Rev., (2) **6**: 75–77. 1915.

HERSEY, M. D *On the laws of lubrication of journal bearings.* Journ. Am. Soc. Mech. Engs., **37**: 534–538. 1915; Trans. Am. Soc. Mech. Engs., **37**: 167–202. 1915.

HERSEY, M. D. *Discussion of Edgar Buckingham's paper on model experiments.* Journ. Am. Soc. Mech. Engs., **37**: 532–533. 1915.

HULETT, G. A., and VINAL, G. W. *Studies on the silver voltameter.* J. Phys. Chem., **19**: 173–192. 1915; Bur. Stds. Sci. Paper No. 240 (Bull. Bur. Stds., **11**: 553–570). 1915.

HUMPHREYS, W. J. *The thunderstorm.* Phys. Rev., (2) **6**: 516. 1915.

IVES, H. E., COBLENTZ, W. W., and KINGSBURY, E. F. *The mechanical equivalent of light.* Phys. Rev., (2) **5**: 269–293. 1915.

KOLSTER, FREDERICK A. *Ein direkt anzeigender Dekrement- und Wellenmesser.* Jahrb. d. drahtl. Teleg. und Teleph., 1915, pp. 316–339. 1915; Bur. Stds. Sci. Paper No. 235 (Bull. Bur. Stds., **11**: 421–455). 1915.

LASIER, E. L. *The strength of clamped splices in concrete reinforcement bars.* Proc. A. S. T. M., vol. 16. 1916; Eng. News. **76**: 134. 1916; Eng. Record, July 8, 1916; Cement Era, July, 1916. 1916.

LASIER, E. L. *Tests of frictional resistance of concrete on shale.* Eng. News, **74**: 156–158. 1915.

MCCOLLUM, BURTON, and AHLBORN, G. H. *Procedure in making electrolysis surveys.* Bur. Stds. Tech. Paper No. 28. Pp. 84. 1916.

MIDDLEKAUFF, G. W., and SKOGLAND, J. F. *Photometry of gas-filled lamps.* Bur. Stds. Sci. Paper No. 264 (Bull. Bur. Stds., **12**: 587–604). 1916.

MIDDLEKAUFF, G. W., MULLIGAN, B., and SKOGLAND, J. F. *Life testing of incandescent lamps at the Bureau of Standards.* Bur. Stds. Sci. Paper No. 265 (Bull. Bur. Stds., **12**: 605–630). 1916; Trans. Ill. Eng. Soc., **10**: 814–837. 1915.

MIDDLEKAUFF, G. W., and SKOGLAND, J. F. *An interlaboratory photometric comparison of glass screens and of tungsten lamps, involving color differences.* Bur. Stds. Sci. Paper No. 277 (Bull. Bur. Stds., **13**: 287–307). 1916; Trans. Illum. Eng. Soc., **11**: 164–183. 1916.

MILLER, J. M. *The effective resistance and inductance of iron and bimetallic wires.* J. Wash. Acad. Sci., **5**: 455–456. 1915: Bur. Stds. Sci. Paper No. 252 (Bull. Bur. Stds., **12**: 207–267). 1915.

MILLER, J. M. *The effect of imperfect dielectrics in the field of a radiotelegraphic antenna.* Bur. Stds. Sci. Paper No. 269 (Bull. Bur. Stds., **13**: 129–136). 1916.

PETERS, O. S. *Protection of life and property against lightning.* J. Wash. Acad. Sci., **5**: 625–628. 1915; Bur. Stds. Tech. Paper No. 56. Pp. 127. 1915.

PRIEST, IRWIN G. *A proposed method for the photometry of lights of different colors.* Phys. Rev., (2) **6**: 64–66. 1915.

PRIEST, IRWIN G. *Some devices used in evaluating certain trigonometric and exponential functions occurring in photometry.* Phys. Rev., (2) **7**: 414. 1916.

PRIEST, IRWIN G. *The Bureau of Standards' contrast method for measuring transparency.* Trans. Amer. Ceramic Soc., vol. 17. Pp. 17. 1915.

PRIEST, IRWIN G., and PETERS, CHAUNCEY G. *Report on investigations concerning the color and spectral transmission of cotton seed oil.* Proc. Sixth Ann. Conv. Soc. Cotton Products Analysts. Pp. 67–80. 1915.

ROSA, E. B., and TAYLOR, A. H. *The integrating sphere, its construction and use.* Trans. Illum. Eng. Soc., **11**: 453–478. 1916.

ROSA, E. B., and VINAL, G. W. *The volume effect in the silver voltameter.* Bur. Stds. Sci. Paper No. 283 (Bull. Bur. Stds., **13**: 447–457). 1916.

ROSA, E. B., and VINAL, G. W. *Summary of experiments on the silver voltameter at the Bureau of Standards.* J. Wash. Acad. Sci., **6**: 478–481. 1916.

ROSA, E. B., and VINAL, G. W. *Summary of experiments on the silver voltameter at the Bureau of Standards, and proposed specifications.* Bur. Stds. Sci. Paper No. 285 (Bull. Bur. Stds., **13**: 479–514). 1916.

SCHLINK, F. J. *Weighing scales.* Machinery, **22**: 968–973. 1916.

SCHLINK, F. J. *Automatic scales.* Tenth Ann. Conf. Weights and Meas., pp. 95–108. 1916.

SCHLINK, F. J. *Damping devices in precise weighing.* Scale Journ., April, 1916.

SCHLINK, F. J. *Method of indicating screw threads.* Machinery, **22**: 800. 1916.

SCHLINK, F. J. *A use for the cone pivot.* Scale Journ., April, 1916.

SILSBEE, F. B. *Inductance of copper conductors at close spacing.* Elec. World, **68**: 125–126. 1916.

SILSBEE, FRANCIS B. *A study of the inductance of four-terminal resistance standards.* J. Wash. Acad. Sci., **6**: 419–421. 1916; Bur. Stds. Sci. Paper No. 281 (Bull. Bur. Stds., **13**: 375–422). 1916.

SKOGLAND, J. F. *A direct-reading device for use in computing characteristics of vacuum tungsten lamps.* J. Wash. Acad. Sci., **5**: 453–455. 1915; Bur. Stds. Sci. Paper No. 253 (Bull. Bur. Stds., **12**: 269–288). 1915.

SMITH, W. S. TANGIER. *Polarized skylight and the petrographic microscope.* J. Wash. Acad. Sci., **6**: 229–234. 1916.

STRATTON, S. W. *Annual report of the Director of the Bureau of Standards, 1914–1915.* Pp. 148. 1915.

STILLMAN, M. H. *A new method for the accurate testing of cubic foot bottles and other large capacity measures. (A method depending upon Archimedes principle of buoyancy).* Scale Journ., vol. 2, No. 1. 1915.

STILLMAN, M. H. *The damping of waves and other disturbances in mercury.* Bur. Stds. Sci. Paper No. 289 (Bull. Bur. Stds., vol. 13). 1916.

SWANN, W. F. G. *On the origin and maintenance of the earth's negative charge.* Phys. Rev., (2) **6**: 508. 1915.

SWANN, W. F. G. *On the ionization of the upper atmosphere.* J. Terr. Mag., **21**: 1–8. 1916.

SWANN, W. F. G. *Equipartition of energy and radiation theory.* Phys. Rev., (2) **7**: 154–156. 1916.

TAYLOR, W. A., and CURTIS, H. L. *An accurate method for the measurement of the conductivity of electrolytes.* Phys. Rev., (2) **6**: 61–64. 1915.

VINAL, G. W., and BOVARD, W. M. *Inclusions in the silver voltameter deposits.* J. Amer. Chem. Soc., **38**: 496–515. 1916; Bur. Stds. Sci. Paper No. 271 (Bull. Bur. Stds., **13**: 147–172). 1916.

WENNER, FRANK. *A method of measuring earth resistivity.* J. Wash. Acad. Sci., **5**: 561–563. 1915; Bur. Stds. Sci. Paper No. 258 (Bull. Bur. Stds., **12**: 469–478). 1915.

WENNER, FRANK. *General design of critically damped galvanometers.* Bur. Stds. Sci. Paper No. 273. (Bull. Bur. Stds., **13**: 211–244). 1916. (A theoretical discussion of the subject.—N. E. D.)

WHITE, WALTER P. *Mechanical strain and thermoelectric power.* Phys. Rev., (2) **6**: 234–236. 1915.

WHITE, WALTER P. *Convection currents and calorimeter design.* Phys. Rev., (2) **7**: 682–683. 1916.

WOLFF, F. A., SHOEMAKER, M. P., and BRIGGS, C. A. *Construction of primary mercurial resistance standards.* J. Wash. Acad. Sci., **5**: 458–461. 1915; J. Franklin Inst., **180**: 104–106. 1915; Bur. Stds. Sci. Paper No. 256 (Bull. Bur. Stds., **12**: 375–464). 1915.

PHYSICAL CHEMISTRY

BLUM, W., HOLLER, H. D., RAWDON, H., and LASIER, E. L. *The deposition of copper in electrotyping baths.* Met. and Chem. Eng., May 1, 1916. 1916.

BUREAU OF STANDARDS. *Regulation of electrotyping solutions.* 2d ed. Circular No. 52. Pp. 13. 1916.

BURGESS, G. K. *Some problems in physical metallurgy at the Bureau of Standards.* J. Franklin Inst., **182**: 19–35. 1916.

BURGESS, G. K., and KELLBERG, I. N. *On a supposed allotropy of copper.* J. Wash. Acad. Sci., **5**: 657–662. 1915; Phys. Rev., (2) **7**: 281–282. 1916.

BURGESS, G. K., and MERICA, P. D. *An investigation of fusible tin boiler plugs.* J. Wash. Acad. Sci., **5**: 461–462. 1915; Bur. Stds. Tech. Paper No. 53. Pp. 37. 1915.

BURGESS, G. K., and SALE, P. D. *A study of the quality of platinum ware.* Bur. Stds. Sci. Paper No. 254 (Bull. Bur. Stds., **12**: 289–316). 1915; J. Ind. and Eng. Chem., **7**: 561. 1915.

BURGESS, G. K., and SCOTT, H. *Mesure thermoélectrique des points critiques du fer.* Comptes rendus d. l'Acad. d. Sci., **163**: 30. 1916.

RAWDON, HENRY S. *Microstructural changes accompanying the annealing of bronze.* J. Wash. Acad. Sci., **5**: 589–591. 1915; Bur. Stds. Tech. Paper No. 60. Pp. 17. 1915.

RAWDON, HENRY S. *Standard zinc-bronze, relation of micro-structure and mechanical properties.* J. Wash. Acad. Sci., **5**: 631–632. 1915; Bur. Stds. Tech. Paper No. 59. Pp. 67. 1915.

SOSMAN, R. B., HOSTETTER, J. C., and MERWIN, H. E. *The dissociation of calcium carbonate below 500°C.* J. Wash. Acad. Sci., **5**: 563–569. 1915.

WELLS, ROGER C. *The solubility of calcite in water in contact with the atmosphere, and its variation with temperature.* J. Wash. Acad. Sci., **5**: 617–622. 1915.

GEOLOGY

ALLEN, E. T. *The composition of natural bornite.* Amer. Journ. Sci., **41**: 409–413. 1916.

BECKER, GEORGE F., and DAY, ARTHUR L. *Note on the linear force of growing crystals.* Journ. of Geology, **24**: 313–333. 1916.

BLISS, ELEANOR F., and JONAS, ANNA I. *Relation of the Wissahickon mica gneiss to the Shenandoah limestone and Octoraro schist of the Doe Run and Avondale region, Chester County, Pennsylvania.* U. S. Geological Survey Professional Paper 98-B. Pp. 25, with illustrations. 1916.

BOWEN, N. L. *The later stages of the evolution of the igneous rocks.* Journ. of Geology, **23**: Supplement to Number 8. Pp. 89. 1915.

CAPPS, STEPHEN R. *Two glacial stages in Alaska.* Journ. of Geology, **23**: 748–756. 1915.

IDDINGS, JOSEPH P., and MORLEY, EDWARD W. *Contributions to the petrography of Java and Celebes.* Journ. of Geology, **23**: 231–245. 1915.

JOHNSTON, J., MERWIN, H. E., and WILLIAMSON, E. D. *The several forms of calcium carbonate.* Amer. Journ. Sci., **41**: 473–512. 1916.

LEE, WILLIS T. *Reasons for regarding the Morrison as an introductory Cretaceous formation.* Bull. Geol. Soc. Amer., **26**: 303–314. 1916.

LEFFINGWELL, E. DE K. *Ground-Ice wedges. The dominant form of Ground-Ice on the north coast of Alaska.* Journ. of Geology, **23**: 635–654. 1915.

LINDGREN, W. *Processes of mineralization and enrichment in the Tintic District.* Economic Geology, **10**: 225–240. 1915.

LINDGREN, W. *The origin of kaolin.* Economic Geology, **10**: 89–93. 1915.

LLOYD, E. RUSSELL, and HARES, C. J. *The Cannonball marine member of the Lance formation of North and South Dakota and its bearing on the Lance-Laramie problem.* Journ. of Geology, **23**: 523–547. 1915.

PAIGE, SIDNEY. *The mechanics of intrusion of the Black Hills (S. D.) pre-Cambrian granite.* Proc. Nat. Acad. Sci., **2**: 113–114. 1916.

SOSMAN, ROBERT B. *Types of prismatic structure in igneous rocks.* Journ. of Geology, **24**: 215–234. 1916.

STANTON, T. W. *Invertebrate fauna of the Morrison formation.* Bull. Geol. Soc. Amer., **26**: 343–348. 1915.

VAUGHAN, T. W. *The present status of the investigation of the origin of the Barrier coral reefs.* Amer. Journ. Sci., **41**: 131–134. 1916.

WASHINGTON, H. S., and DAY, ARTHUR L. *Present condition of the volcanoes of southern Italy.* Bull. Geol. Soc. Amer., **26**: 375–388. 1916.

WRIGHT, FRED. E. *Obsidian from Hrofntinnuhryggur, Iceland. Its lithophysae and surface markings.* Bull. Geol. Soc. Amer., **26**: 225–286. 1915.

ENTOMOLOGY

BACK, E. A., and PEMBERTON, C. E. *Banana as a host fruit of the Mediterranean fruit fly.* Journal of Agricultural Research, **5**: 793–804, pls. 59–62. January 24, 1916.

BACK, E. A., and PEMBERTON, C. E. *Effect of cold-storage temperatures upon the Mediterranean fruit fly.* Journal of Agricultural Research, **5**: 657–666. January 10, 1916.

BAKER, A. C. *Identity of* Eriosoma Pyri. Journal of Agricultural Research, **5**: 1115–1120, fig. 1. March 6, 1916.

BAKER, A. C., and TURNER, W. F. *Morphology and biology of the green apple aphis.* Journal of Agricultural Research, **5**: 955–994, figs. 1–4, pls. 67–75. February 21, 1916.

HERRICK, G. W., and MATHESON, ROBERT. *Observations on the life history of the cherry leaf beetle.* Journal of Agricultural Research, **5**: 943–950, pls. 64–65. February 14, 1916.

JOHNSON, PAULINE M., and BALLINGER, ANITA M. *Life-history studies of the Colorado potato beetle.* Journal of Agricultural Research, **5**: 917–926, pl. 63. February 14, 1916.

PARROTT, P. J., and FULTON, B. B. *Cherry and hawthorn sawfly leaf miner.* Journal of Agricultural Research, **5**: 519–528, pl. 51. December 20, 1915.

TOWER, D. G. *Biology of* Apanteles militaris. Journal of Agricultural Research, **5**: 495–508, fig. 1, pl. 50. December 20, 1915.

ENGINEERING

GROVER, NATHAN C., HENSHAW, F. F., BALDWIN, G. C., and LAMB, W. A. *Surface water supply of the United States, 1912, Part XII, north Pacific drainage basins.* United States Geological Survey Water-Supply Paper 332. Pp. 748. 1916.

MARSHALL, R. B. *Spirit leveling in West Virginia, 1896 to 1915 inclusive.* U. S. Geological Survey Bulletin 632. Pp. 168, with one illustration. 1916.

MARSHALL, R. B. *Spirit leveling in Maine, 1899–1915.* U. S. Geological Survey Bulletin 633. Pp. 64, with one illustration. 1916.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE WASHINGTON ACADEMY OF SCIENCES

The 112th meeting of the Washington Academy of Sciences was held in the Auditorium of the New National Museum, Thursday evening, May 11, 1916, with President L. O. HOWARD in the chair and a large audience present.

Dr. ERWIN F. SMITH, Chief of the Laboratory of Plant Pathology, Bureau of Plant Industry, delivered an illustrated lecture on *Resemblances between crown gall in plants and human cancer.* The speaker reviewed the objections that have been raised to the theory that cancer is of bacterial origin, and showed that such objections do not rest upon a sound experimental basis. He then developed the striking parallelism which exists between human cancer and crown-gall in plants, the latter being of unquestioned bacterial origin and readily developed by inoculation with pure cultures.

The address has been published in *Science* (New Series, **43**: 871–889. June 23, 1916) under the title, *Further evidence that crown gall of plants is cancer.*

W. J. HUMPHREYS, *Recording Secretary.*

THE GEOLOGICAL SOCIETY OF WASHINGTON

The 309th meeting of the Society was held in the lecture room of the Cosmos Club on April 26, 1916.

REGULAR PROGRAM

K. F. KELLERMAN: *Bacteria as agents in the precipitation of calcium carbonate.* Precipitation of calcium carbonate from solutions of calcium sulphate, calcium acetate, and artificial sea water by bacteria. Formation of spherulites. (Illustrated.) No abstract.

JOHN JOHNSTON: *Some factors which influence the deposition of calcium carbonate.* By means of the solubility-product constant of calcite we are enabled to calculate its solubility under various conditions; whence it appears that this solubility is affected materially by variations of the temperature and of concentration of free CO_2 in the water which may well occur in nature. For example, a change in the proportion of CO_2 in the air from 3.2 to 3.0 parts per 10000, or a rise of temperature of 2°C., would result ultimately in the precipitation of about 2 grams $CaCO_3$ from each cubic metre of a solution saturated with it. Consequently, since the warmer portions of the ocean are substantially satu-

rated with calcite, precipitation must take place, independent of any other agencies, wherever the water is being warmed, or is losing free CO_2, or both. This view that this mode of precipitation, brought about by the operation of purely inorganic factors, actually takes place on a large scale, does not exclude the other views which have been proposed to account for the deposition of limestones, and is not in conflict with any facts which are definitely ascertained. It could be established or disproved by systematic bathymetrical and chemical investigation of the ocean, an investigation which would have an important bearing on many biological as well as geological processes.

H. E. MERWIN: *The forms of calcium carbonate and their occurrence.* A new form of calcium carbonate which is hexagonal, optically positive, and less stable than aragonite, was described. It forms readily in solution at about 60°. Criteria for distinguishing the three established forms of calcium carbonate were discussed, and the necessity for distinguishing the properties of aggregates from those of definitely bounded crystal fragments was emphasized in connection with evidence which was given to show that "vaterite" is really porous calcite and that "ktypeite" is porous aragonite. The precipitation of aragonite is favored by the presence of sulphate, but magnesium has little influence. Sulphate is taken into solid solution in aragonite in sufficient quantity to make it more stable probably than calcite. Aragonite containing sulphate was separated from muds of the shoal waters of the Bahamas. Four types of original structure of oölites were described and illustrated.

Discussion led by T. WAYLAND VAUGHAN, CHAS. D. WALCOTT, G. R. MANSFIELD.

The 310th meeting was held in the lecture room of the Cosmos Club on May 10, 1916.

INFORMAL COMMUNICATIONS

FRED. E. WRIGHT described a more delicate method than those usually employed for determining isotropic and anisotropic character in opaque minerals.

REGULAR PROGRAM

HENRY S. WASHINGTON: *The persistence of the volcanic vents at Stromboli.* When Stromboli was visited in August, 1914, it was in a state of moderate activity, there being five vents on the crater terrace. The most active of these, that at the east end of the upper edge of the Sciarra, is called "l'antico," and Bergeat pointed out in 1899 that this vent had probably occupied the same location for over a hundred years. Search through the literature yielded evidence, especially in the form of sketches and plans of the crater terrace, favoring Bergeat's view, and going to show that not only this vent, but also another on the west, scarcely less active in 1914, have not materially altered their

positions for a period of at least about a century and a half. It may be mentioned that the crater of Stromboli is an exceptionally favorable one for the study of such a feature, as it is bounded on two sides by prominent ridges, one or both of which appear in all views and plans, that form permanent landmarks by which the relative positions of the several vents at different dates can be readily established. A series of about 15 of these views and plans, dating back to 1768, was shown.

This feature of Stromboli, and possibly of other volcanoes, as it seems to be presented at Kilauea and elsewhere, does not appear to have been generally recognized. It would, however, seem to have an important bearing on certain volcanological problems, such as, among others, the size of the lava reservoir immediately beneath the crater floor. Such a persistence of location of volcanic vents apparently favors Daly's view that the size of volcanic conduits is small, rather than Dana's, that they are nearly commensurate in size with the whole crater floor. The formation of these relatively small vents may possibly be explained by Daly's "gas-fluxing" hypothesis.

F. C. SCHRADER: *Ore deposits of the Rochester district, Nevada.* The deposits consist of silver and gold-bearing veins, lodes, and associated replacement bodies. They occur in volcanic rocks which are chiefly rhyolites of Triassic age. The rocks, nearly 2,000 feet in thickness, dip gently to the east. The veins dip steeply to the west. In some of them good ore bodies are opened to the depth of a thousand feet.

The deposits lie in two north-south belts, Henzel Hill belt on the east and Lincoln Hill belt on the west, which are about two miles apart, each a mile wide and five miles long. In the Henzel Hill belt they are chiefly silver-bearing, in the Lincoln Hill belt gold-bearing.

Henzel Hill belt near its middle point contains Henzel Hill, an oval silicified knob 3000 feet long, the seat of the most important deposits. Here the deposits occur in and associated with fissures, joint planes, and shear zones. Some of them are 40 feet in width. The ores which average about $20 to the ton contain chiefly silver but carry also several dollars to the ton in gold, which increases in amount with depth.

The ore minerals are chiefly argentite and sulphantimonites with a little associated proustite, cerargyrite, bromyrite, pyrargyrite, scales of native silver, and specks of free gold. From the 200-foot level down the ore minerals are mostly sulphides.

At Packard, 2 miles south of Henzel Hill, the deposits occur as massive replacement ore beds, nearly 100 feet in maximum width, in soft schistose rhyolite. They contain but little quartz. The ore minerals are chiefly cerargyrite and argentite. Most of the ore produced up to 1916 averaged in silver about $50 to the ton.

In the Lincoln Hill belt the deposits are more distinctly narrow veins of the filled fissure type. The gangue is quartz which contains almost exclusively free gold ores, averaging about $140 to the ton, with some that are very rich. The associated minerals are pyrite, arsenopyrite,

tourmaline, specularite, argentite, bromyrite, and a gold telluride. Some of the gold is coarse, which fact suggests that these veins probably represent an important source of the rich placers mined in neighboring Spring Valley and American Canyon.

From the presence of minerals of deep-seated origin, the replacement character of the deposits, and hydrothermal alteration of the rocks, the Rochester deposits seem to have been formed at relatively high temperatures and at considerable depth. Their origin is referred to magmatic solutions and gases emanating from post-Jurassic granite, which as a batholithic mass intrudes the rocks on the north and is believed to extend beneath the district. The deposits therefore are probably of early Cretaceous age.

From the deep-seated character of the deposits and their close association with the major geologic structures which are very persistent, it is believed that some of the deposits may extend to considerable depth.

W. C. ALDEN: *The Iowan stage of glaciation—a review of the evidence based upon field studies in 1914 and 1915, by the United States and Iowa Geological Surveys.* For résumé of the facts presented in this paper see Bull. Geol. Soc. Amer., **27**: 117–119. 1916.

CARROLL H. WEGEMANN, *Secretary.*

THE BIOLOGICAL SOCIETY OF WASHINGTON

The 557th regular meeting was held at the Cosmos Club on May 20, 1916; called to order by President HAY at 8 p.m.; 30 persons present.

On recommendation of the Council, JAMES L. PETERS was elected to active membership.

The President announced that the Council of the Society had voted to adopt the custom of the medical and of many other scientific societies of allowing members to speak but once during the discussion of a paper and of asking the original speaker to answer all questions at the end of the discussion and to close the same.

Under the heading of *Brief notes and exhibition of specimens,* Dr. HOWARD E. AMES referred again to the dorsally placed mammae of the coypu (*Myocastor coypu*) and exhibited photographs of a female coypu in the collection of the Philadelphia Zoological Society showing the mammae so placed.

The first paper of the *Regular program* was by A. T. SPEARE: *Some fungi that kill insects.* Mr. Speare spoke briefly of certain experiments that were conducted in Europe about 1885, in which the "green muscardine" fungus was used in a practical way to combat the cockchafer of wheat. Reference was also made to similar work that has recently been conducted in Florida, and Trinidad, B. W. I. The writer spoke also of the present status of the chinch bug disease and of the brown tailed moth disease. In regard to the latter he spoke in detail of the methods employed in spreading this disease in the field. At the end of the paper he exhibited slides illustrating various types of entomog-

enous fungi, some of which were collected by him in the Hawaiian Islands. Mr. Speare's communication was discussed by General T. E. WILCOX and by Dr. L. O. HOWARD.

The second paper was by L. O. HOWARD: *The possible use of Lachnosterna larvae as a food supply.* Dr. Howard briefly referred to the prejudice against insects as food and gave an account of his experiments recently undertaken with white grubs sent in from Wisconsin. They were sterilized, thoroughly washed, the contents of the alimentary canal removed, and were then served as a salad and in a broth. They were eaten by several members of the Bureau of Entomology and by Mr. VERNON BAILEY of the Biological Survey and were pronounced distinctly edible. The speaker urged further experimentation with numerous species of insects as to their food value. Dr. Howard's communication was discussed by the Chair, Mr. W. E. SAFFORD, General WILCOX and Medical Inspector AMES.

The last paper was by W. E. SAFFORD: *Agriculture in pre-Columbian America.* Mr. SAFFORD described various plants used by the early inhabitants of America, particularly those of Mexico and of Central and South America, and the manner of their use and preparation, and called attention to those employed at the present day and adopted by civilized man. The prominent part which these plants played in the life of the pre-Columbian inhabitants is shown in ceremonial objects, earthenware products, etc., ornamented by designs based on these plants and in some cases by molds of parts of plants. Mr. Safford's communication was illustrated by numerous lantern slide views of the plants under consideration and of many objects bearing plant designs. It was discussed by the Chair, General WILCOX and by Prof. E. O. WOOTON.

M. W. LYON, JR., *Recording Secretary.*

VOLUME 4 NUMBER 1